NEW YORK FISH AND GAME JOURNAL

VOLUME 8 JANUARY, 1961 NUMBER 1

AGE AND GROWTH OF THE FLUKE IN GREAT SOUTH BAY AND THEIR SIGNIFICANCE TO THE SPORT FISHERY[1]

John C. Poole

Conservation Biologist
New York State Conservation Department

ABSTRACT

The age of fluke collected in Great South Bay was determined from annular markings on the otolith bone (sagitta). Growth was back-calculated according to the annuli for 357 fish taken in 1958 and 1959. Female fish grew significantly faster than males, reaching mean total lengths of 27.1, 37.7 and 46.5 centimeters at the time of formation of Annuli I, II and III, respectively. The corresponding figures for male fluke were 25.1, 32.6 and 38.7 centimeters. The sport fishery in 1958 and 1959 landed 1- and 2-year-old fluke primarily. These two age groups comprised 77 per cent of the catch in 1958 and 90 per cent in 1959. The sport fishery was dependent almost directly upon the success of spawning in the previous year, for 45 per cent of the fish taken by hook and line in 1958 and 66 per cent of those taken in 1959 were 1 year old. This dependence upon 1-year-olds provides evidence that marked annual fluctuations n abundance are due chiefly to differences in spawning success from year to year.

Research on the fluke (*Paralichthys dentatus*) has been largely in response to interest in its migration habits and concern over the effects of the winter trawl fishery which had its beginning about 1920 off the Virginia and North Carolina coasts. Pearson (1932) described this fishery and reported upon the landings and size composition of the catch. Neville *et al.* (1939) reported observations on the fluke fishery of New York and mentioned a marked decline in the catch. Westman (1946) described local movements and seasonal migration of this species from tagging experiments conducted in the southshore region of Long Island (N. Y.). His studies revealed that fluke which spend the summer months in the inshore waters of New York were available during the winter months to the offshore trawl fishery off the Virginia capes and that the fishing intensity was high. Because of this, Westman recommended a uniform size limit throughout the range of the fish and careful harvest of the population.

Hildebrand and Shroeder (1928) reported upon studies of age and growth of fluke based upon length frequencies of fish taken in Chesapeake Bay. Until recently, however, there was not sufficient interest to warrant study of the age and growth of the fluke by means of scale or otolith examination. Such information is an important tool in the management of any fishery, and the present paper describes studies conducted from 1956 through 1959 concerning this phase of the life history of the species.

[1] A contribution of Federal Aid in Fish and Wildlife Restoration Project F-15-R. The author is indebted to Dr. Ralph Hile of the U. S. Fish and Wildlife Service for his advice regarding the use of a correction factor in calculations of fish length and to Dr. Bayard Brathstrom of Adelphi College for photographing otoliths.

The work on age and growth was part of an investigation of the sport fishery of Great South Bay and of the life history of the fluke. This investigation was prompted by repeated reports by fishermen of declining catches and unusually reduced landings in late summer. The background, purposes, techniques and preliminary findings of the investigation were reported by Alperin and Poole (1956).

METHODS

During a tagging program in Great South Bay in 1956 scale samples from the caudal peduncle above the lateral line were collected from 50 fluke. These were examined with a binocular microscope, a compound microscope and a projector, but no annular marks could be distinguished.

The otolith was then considered as a key to the determination of age and growth. This bone, largest of three found in the inner ear, has been used in age determination of fish since about 1900. Its structure, function and a history of its use in aging fish were reviewed by Moore (1947) and Fitch (1951). Examination of a sample of 100 otoliths collected in 1957 revealed their usefulness, for, beyond a dark central core, concentric hyaline bands separated by narrow opaque rings were evident. These opaque rings appeared to be formed in late winter and early spring, for otoliths collected in May and June exhibited small hyaline increments beyond the opaque rings and late-summer specimens had large hyaline increments. There were, however, insufficient samples of young fluke in 1957 to determine how many years of growth were represented by the dark central core.

A sampling of the fluke population in Great South Bay by otter trawl was undertaken in 1958 and 1959 at four locations (Figure 1).

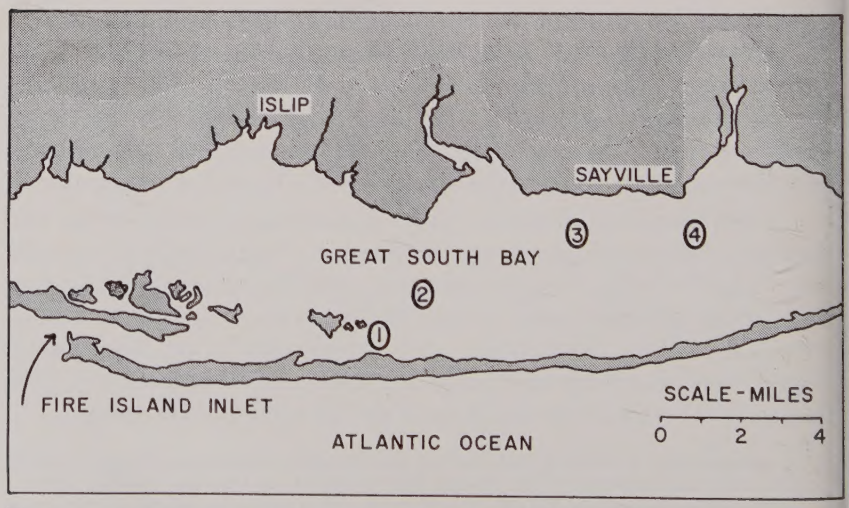


Figure 1. Locations of sampling areas in Great South Bay.

From the samples, which were collected throughout the summer months, left otoliths (sagitta) were removed and stored in labeled vials in a 3 per cent tri-sodium phosphate solution as recommended by Clemens (1950) and random subsamples were selected. To these were added otoliths from 14 larger specimens so that older fish would be more adequately represented in age and growth studies. During the summer of 1958, young fluke were collected with a 300-foot small-mesh shore seine in the bay and measured, and samples of otoliths were stored for examination.

Prior to examination, otoliths were cleared for 3 days in glycerin. Otoliths were placed in a hanging-drop microscope slide, immersed in glycerin and observed under 9X magnification with a binocular microscope. To reduce errors, a frame was constructed to hold the head of the observer in one position while distances from the center of the core to the annuli and the otolith edge were measured. All measurements were made in units equal to 0.048 millimeter with the aid of an eyepiece micrometer. They were recorded from the midpoint of the core to the left side of the otolith in line with the widest edge, with the concave surface of the left otolith upward and the apex directed away from the observer.

In 1958 during July and September, 890 young fish were measured at the time otolith samples were collected. Examination of the length frequencies recorded for these young revealed that their distribution in any one month approached that of a normal curve (Figure 2). The frequencies showed step-like increments reflecting growth during the summer, and it was concluded, therefore, that these fish belonged to a single year class.

These data were used to establish that these fish were all young of the year (Age Group O). If it were assumed that they had belonged to Age Group I, it would have been necessary to conclude that a body of fish 1 year and 4 months old (arbitrarily choosing February as the time of annulus formation) would attain a modal length of 12 centimeters (July graph in Figure 2) and that this body of fish, when 1 year and 6 months old would attain a modal length of 23 centimeters (September graph in Figure 2). This would have meant that in a period of two months these fish would have almost doubled the length which they required over a year to reach. Knowledge of normal growth made such an assumption impossible, and it was, therefore, established that these fish were young of the year and that their otoliths would be useful in determining the location of the first annulus.

To determine the approximate location of the first annulus, measurements from the center of the core to the edge of the otolith were recorded for 92 subsamples of the young of the year collected in 1958. Percentage frequencies of these measurements demonstrated increments of otolith

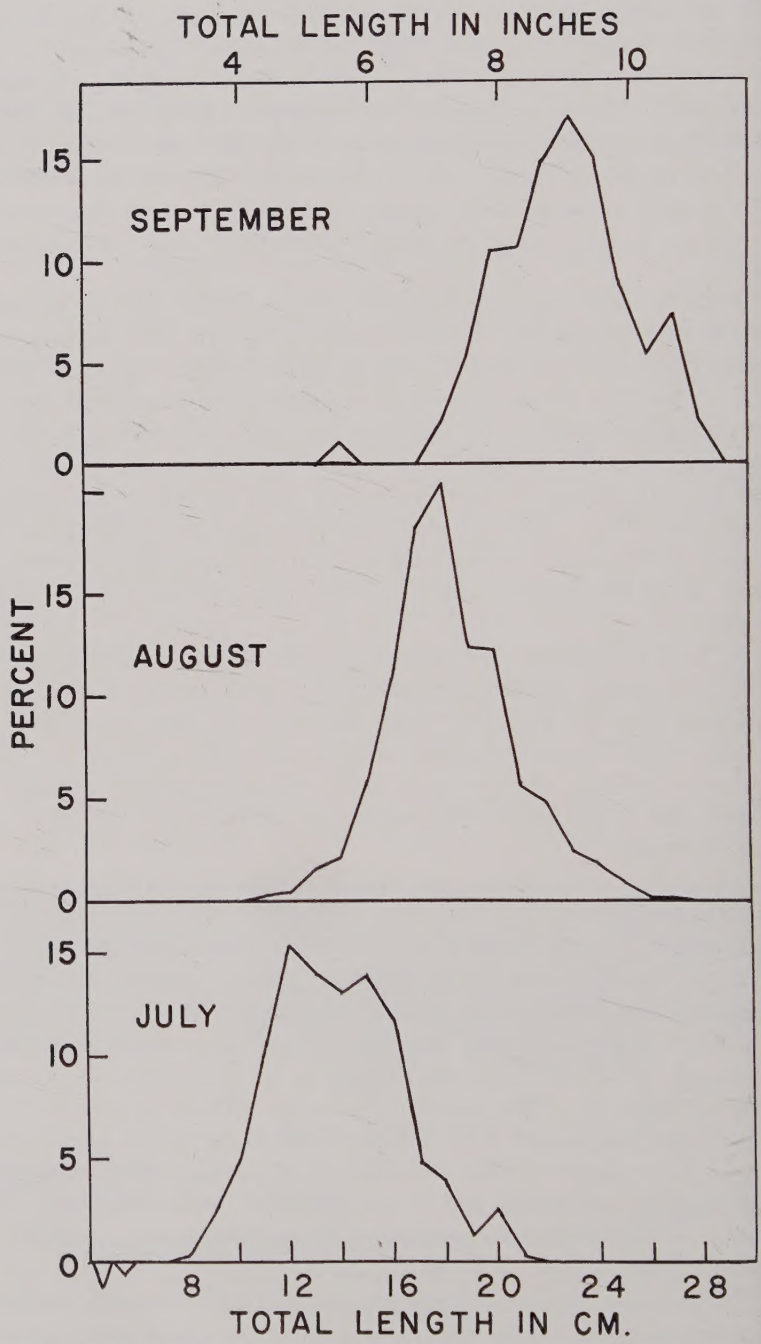
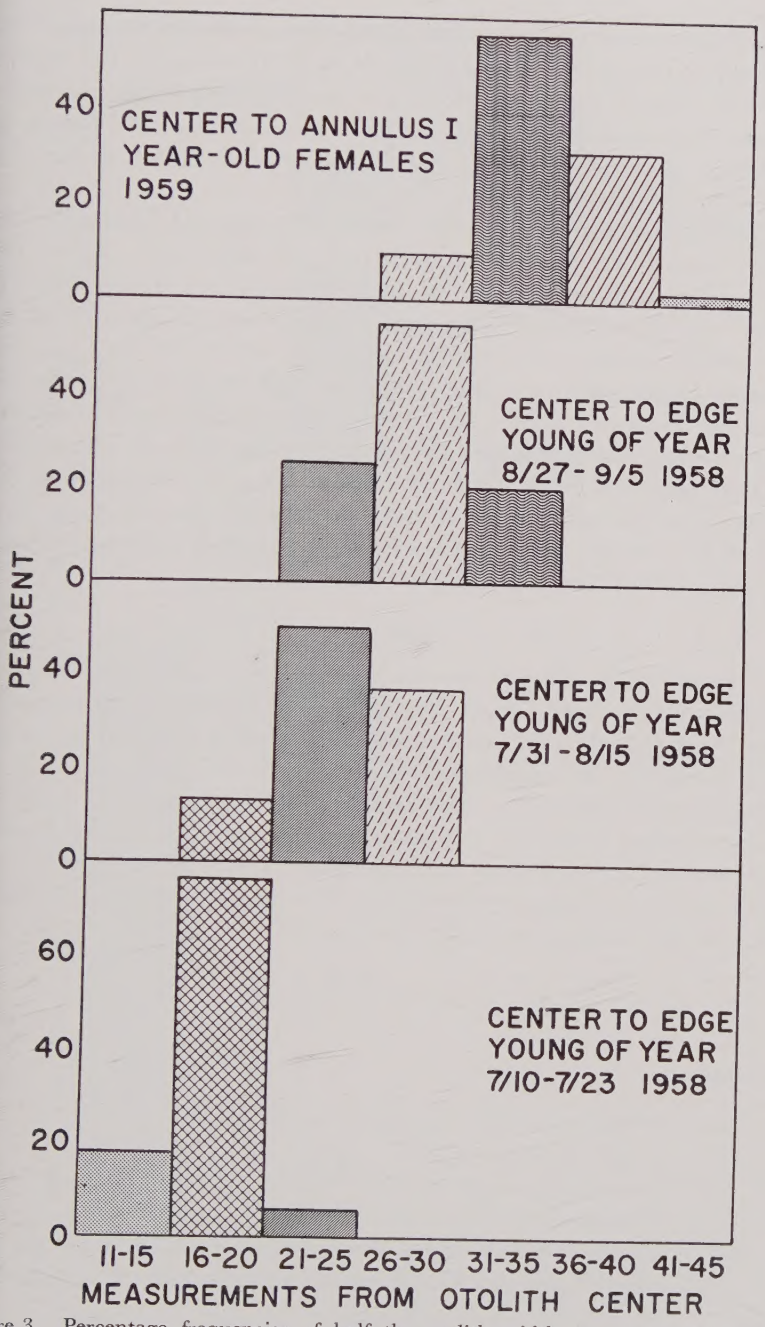


Figure 2. Percentage length frequencies for young-of-the-year fluke taken in the summer of 1958: July—229 fish; August—567 fish; September—94 fish.



gure 3. Percentage frequencies of half the otolith width for young-of-the-year fluke taken in 1958 (July 10–23—34 fish; July 31–August 15—38 fish; August 27–September 5—20 fish) and of measurements to Annulus I for year-old females taken in 1959 (114 fish). Unit of measurement = 0.048 millimeter.

growth as summer progressed and indicated that the first annulus should appear, on the average, at a distance of 30 to 40 units from the center of the core (Figure 3). Subsequently, measurements to what appeared to be the first annulus were recorded from the otoliths of 114 female fish collected during 1959. Percentage frequencies of these measurements fell within the range anticipated (Figure 3).

Proof that a mark constitutes an annulus depends upon a new one being formed each year at approximately the same time. To establish the validity of the marks seen on the fluke otolith, the distance from the outer one to the otolith edge was measured for two samples of fish. One was a sample of 114 females collected in 1959 that had one mark (Figure 4); the other, a sample of 48 males and females collected in 1958 that had two marks (Figure 5). Percentage frequencies for this measurement during various summer periods demonstrated small increments in early summer and larger increments in later months. Therefore, in both years the marks were formed at approximately the same time and represented true annuli. The appearance of these annuli is illustrated in the accompanying photographs (Figure 6).

RESULTS

To determine the relationship between fish length and one-half the otolith width[2], otoliths from 396 fluke were examined and measured. The linear regression for this relationship was calculated, and the straight line describing the relationship was graphed over plots of the actual measurements (Figure 7). The coefficient of correlation of the regression was computed to be 0.89. With so high a correlation, the relationship was adequately described by a straight line. Therefore, arithmetic values were used in the following formula to determine the length of the fish at the time the various annuli had been formed:

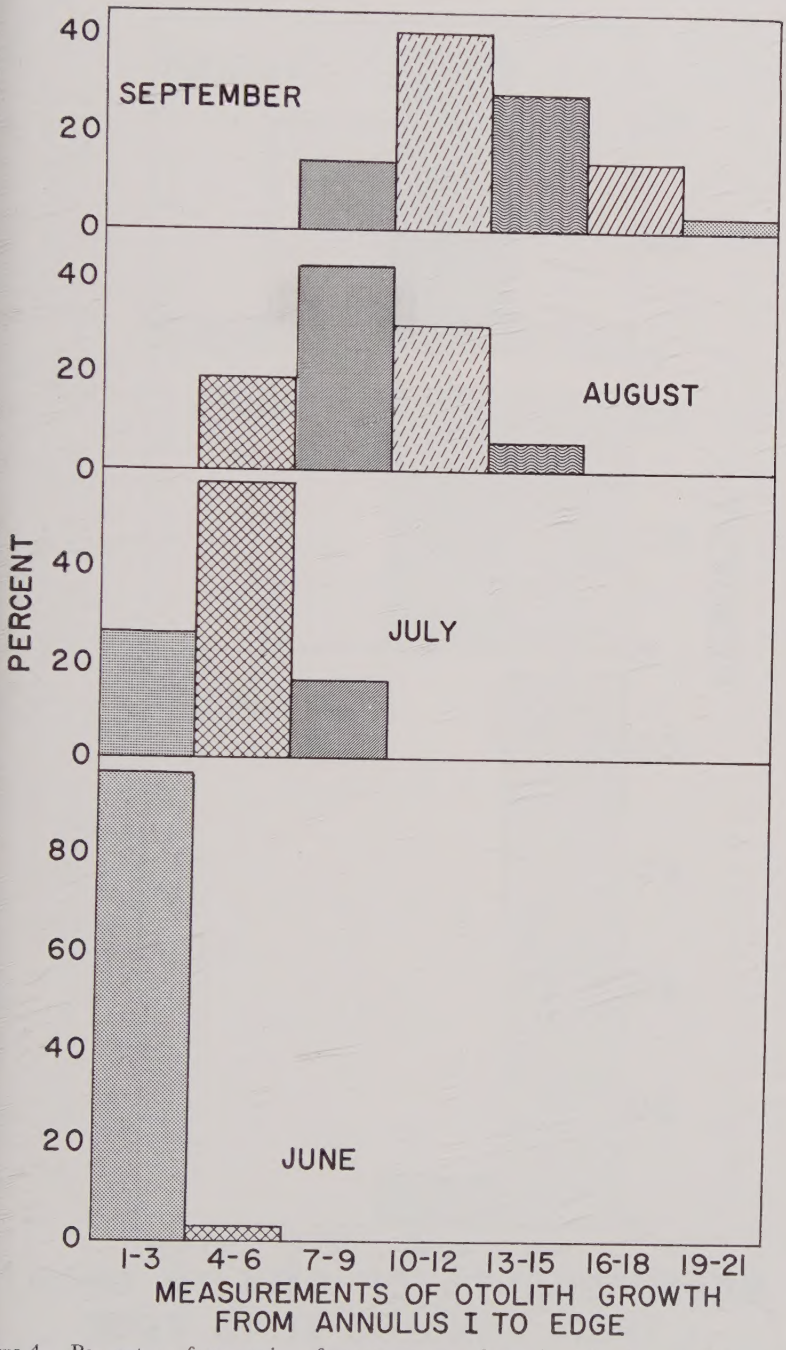
$$L_1 = C + \frac{S_1 (L - C)}{S}$$

in which,

L_1 = length of fish at time of annulus formation
L = length of fish at capture
S_1 = measurement from center of core of otolith to annulus
S = measurement from center of core of otolith to edge
C = X-axis intercept of the straight line which expresses the relationship between the fish length and one-half the otolith width ($C = 9.16$)

Calculations of fish lengths in relation to the various annuli were

[2] Otolith measurements were made from the center of the core.



gure 4. Percentage frequencies of measurements from Annulus I to otolith edge for year-old female fluke taken in 1959: June—30 fish; July—19 fish; August—36 fish; September—29 fish. Unit of measurement = 0.048 millimeter.

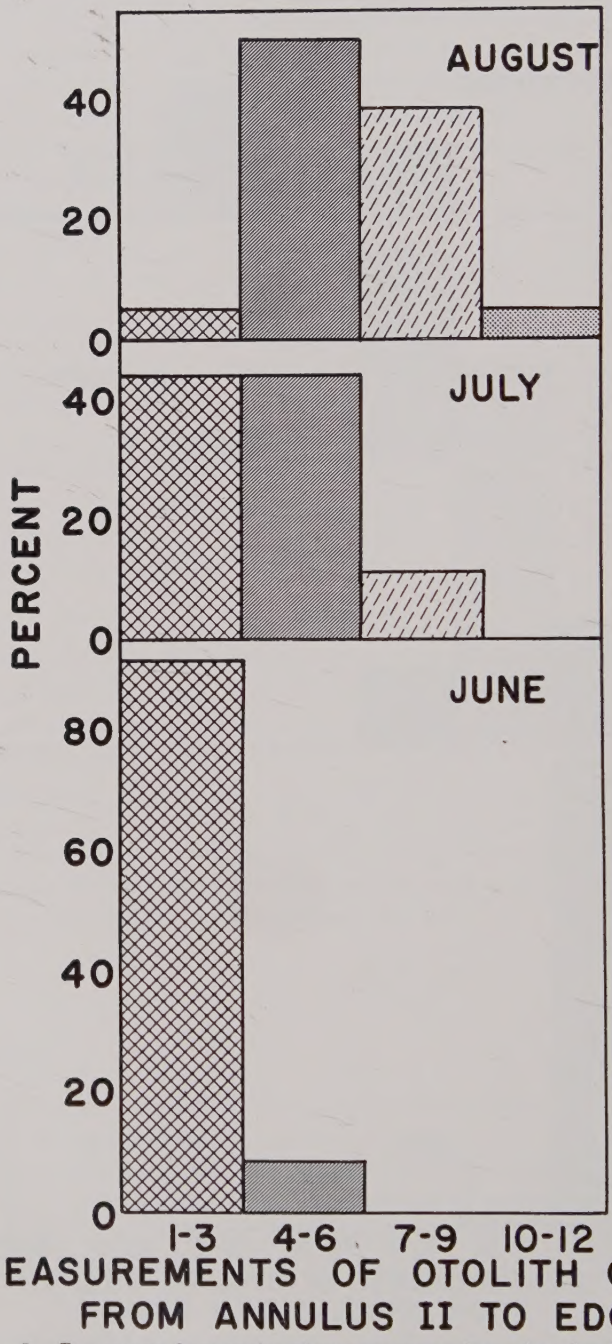
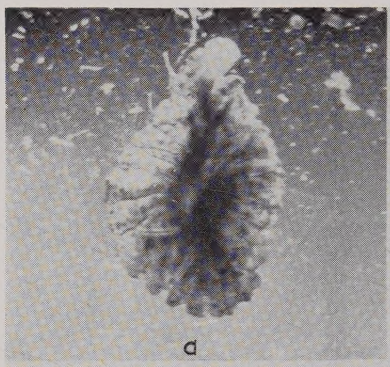


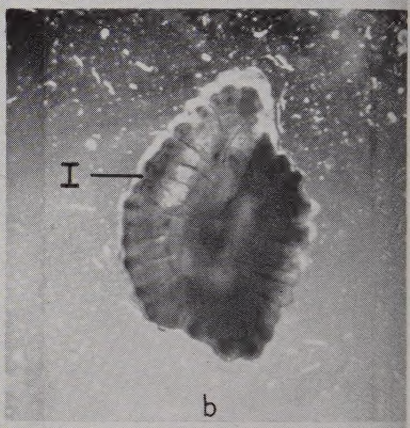
Figure 5. Percentage frequencies of measurements from Annulus II to otolith edge for 2-year-old male and female fluke taken in 1958: June—12 fish; July—18 fish; August—18 fish. Unit of measurement = 0.048 millimeter.

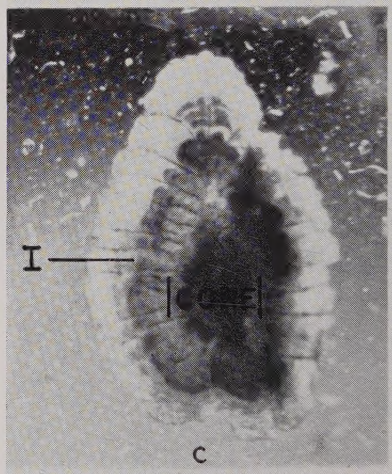
TABLE 1. LENGTH IN RELATION TO VARIOUS ANNULI FOR FLUKE FROM GREAT SOUTH BAY

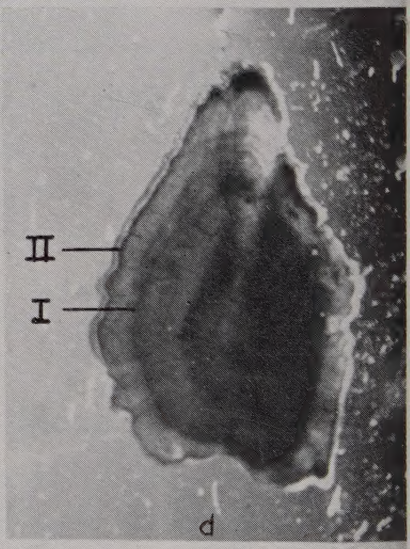
Year class	Annulus I		Annulus II		Annulus III		Annulus IV		Annulus V	
	Number of fish	Length *	Number of fish	Length *	Number of fish	Length *	Number of fish	Length *	Number of fish	Length *
Male										
1954	1	18.3	1	27.4	1	38.2	1	42.7	..	....
1955	8	23.0	8	32.8	8	37.9	..	....	..	....
1956	23	23.5	23	32.9	4	40.3	..	....	..	....
1957	52	25.6	20	32.5	..	....	..	....	..	....
1958	35	26.1	..	....	..	....	..	....	..	....
Total	119	25.1	52	32.6	13	38.7	1	42.7	..	....
Standard deviation	..	3.6	..	2.8	..	3.7	..	0.0	..	....
Female										
1954	4	27.2	4	39.7	4	49.0	4	54.5	1	64.4
1955	6	27.4	6	36.0	6	44.0	2	49.6	..	....
1956	43	26.1	43	38.5	14	46.9	..	....	..	....
1957	71	28.0	34	36.7	..	....	..	....	..	....
1958	114	27.0	..	....	..	....	..	....	..	....
Total	238	27.1	87	37.7	24	46.5	6	53.1	1	64.4
Standard deviation	..	3.1	..	4.0	..	3.9	..	4.9	..	0.0

* In centimeters.


a


I
b


I
c


II
I
d

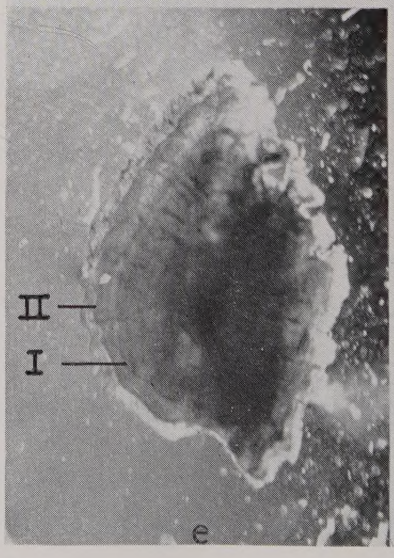

II
I
e

Figure 6. (opposite) Characteristics of otoliths from fluke of different ages.

a. Young-of-the-year, total length 24 centimeters, taken September 5, 1958.

b. One-year-old female, total length 32 centimeters, taken June 5, 1959. Note small increment of growth beyond Annulus I.

c. One-year-old female, total length 38 centimeters, taken September 9, 1959. Note large increment of growth beyond Annulus I.

d. Two-year-old female, total length 42 centimeters, taken July 1, 1959.

e. Two-year-old female, total length 37 centimeters, taken August 3, 1959. Note larger increment of growth beyond Annulus II than exhibited by otolith (d) taken earlier in the summer.

(photographs taken with reflected light from 150-watt photoflood bulb, F 3.5, 1/25 second, 35 mm. reflex camera with photomicrographic attachment)

computed for 357 fish. The resultant data were separated by sex and year class, and the figures are summarized in Table 1.

Mean total lengths when the various annuli were formed were different for male and female fish, the growth rate for females being more rapid. For the age groups for which the samples were adequate (I, II, III), this difference in average total length was significant at the 0.001 level. Graphic representation of the growth rates of the two sexes (Figure 8) demonstrates that in two years females (37.7 centimeters at Age II) almost attained the total length (38.7 centimeters) which male fish required three years to reach.

Figure 8 also illustrates a rapid growth for both sexes during the first year followed by a slower rate in subsequent years. This declining rate is evident in the summary of growth increments between formation of the various annuli (Table 2). Despite this decline, males and females increased 5.8 centimeters and 9.3 centimeters, respectively, between Ages II and III. The significance of these growth increments in relation to the sport fishery are discussed further under conclusions.

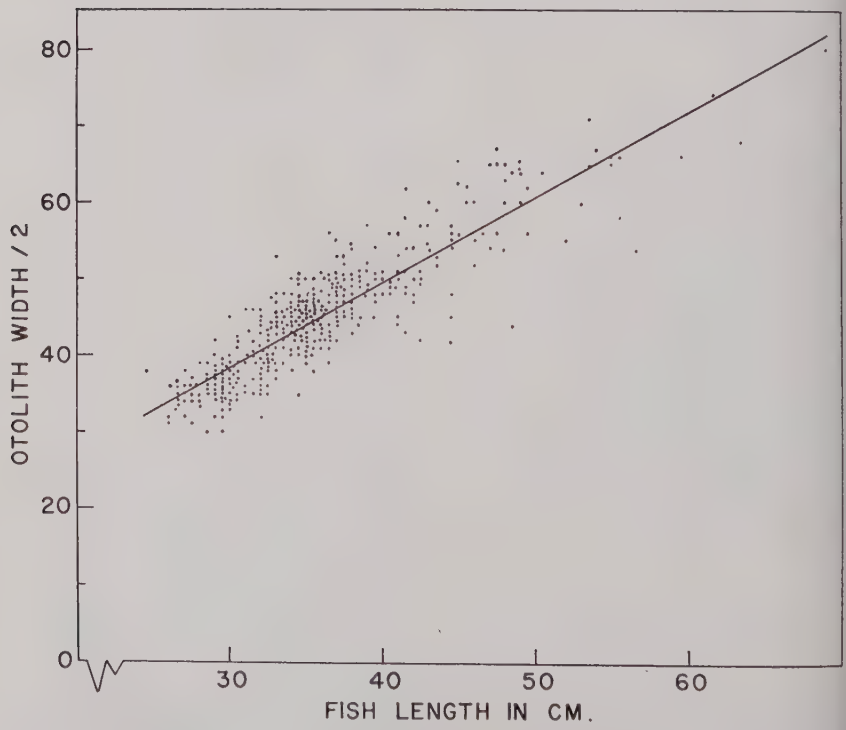


Figure 7. Relationship of half the otolith width to the length of the fish for 385 fluke. Otolith measurements in units equal to 0.048 millimeter. Straight-line relationship expressed by formula: $y = 5.10 + 0.55701x$.

It was difficult to compare growth data from the present study with those determined from length frequencies by Hildebrand and Shroeder (1928). Their study in Chesapeake Bay did not distinguish differential growth between the sexes, aging was approximate, and it is entirely possible that they were measuring more than one species.

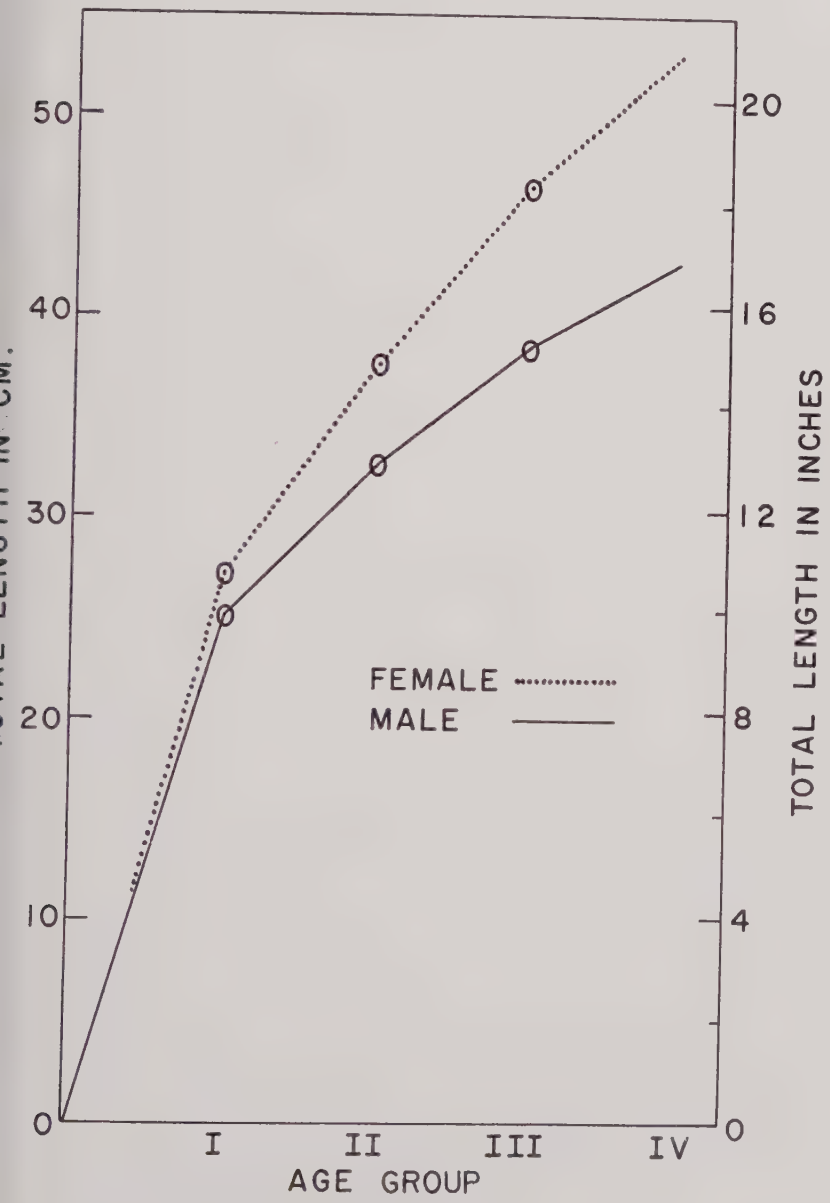


Figure 8. Relative growth rates of male and female fluke.

Table 2. Growth in Relation to Age as Represented by Successive Annuli for Fluke from Great South Bay

Year class	Annuli 0–I		Annuli I–II		Annuli II–III		Annuli III–IV		Annuli IV–V	
	Number of fish	Growth *	Number of fish	Growth *	Number of fish	Growth *	Number of fish	Growth *	Number of fish	Growth *
Male										
1954	1	18.3	1	9.1	1	10.8	1	4.5	..	....
1955	8	23.0	8	9.8	8	5.1	..	....	..	....
1956	23	23.5	23	9.4	4	6.1	..	....	..	....
1957	52	25.6	20	9.0	..	....	..	....	..	....
1958	35	26.1	..	....	..	....	..	....	..	....
Total	119	25.1	52	9.2	13	5.8	1	4.5	..	....
Female										
1954	4	27.2	4	12.5	4	9.4	4	5.9	1	8.3
1955	6	27.4	6	8.6	6	8.0	2	5.3	..	....
1956	43	26.1	43	12.4	14	9.9	..	....	..	....
1957	71	28.0	34	10.1	..	....	..	....	..	....
1958	114	27.0	..	....	..	....	..	....	..	....
Total	238	27.1	87	11.3	24	9.3	6	5.7	1	8.3

* In centimeters.

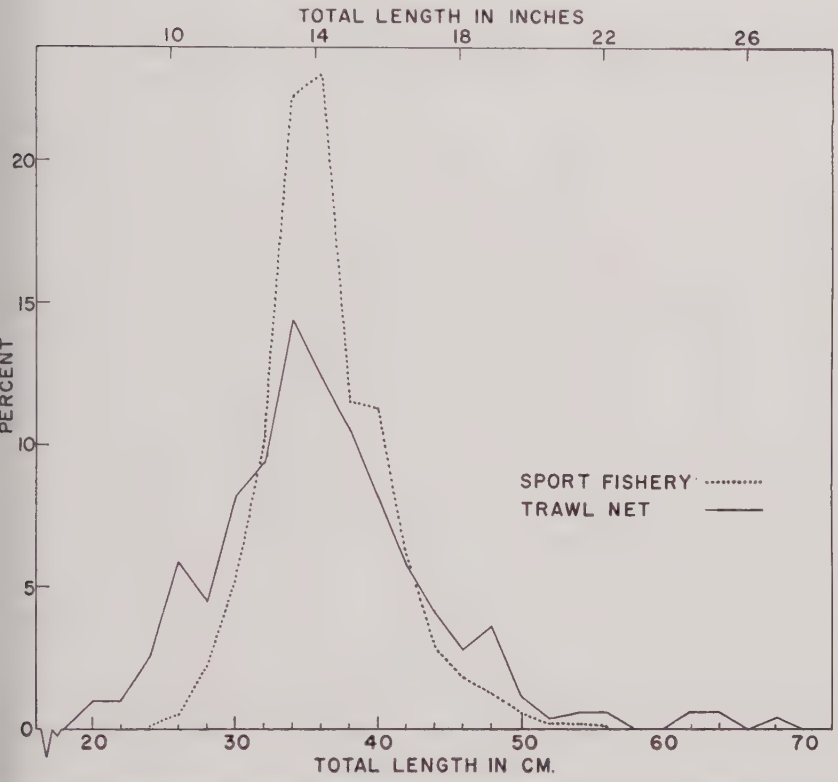


Figure 9. Comparative length distribution of fluke taken by the sport fishery (1,395 fish) and by trawl netting (503 fish) in 1958.

In order to use the age and growth information obtained from the project samples of trawl-caught fluke in an appraisal of the sport fishery in Great South Bay, it was first necessary to compare length frequencies of these samples with similar data from samples of the sport fishery catch. Both samples were collected throughout the summer months of 1958 and 1959. Therefore, the duration of sampling, in addition to the large sample sizes, permitted reliable comparison. The frequencies were graphed (Figures 9 and 10) and demonstrated that the fluke taken by the sport fishery were almost identical in size composition to those taken by the otter-trawl gear in Great South Bay. It was, therefore, possible to conclude that the age composition of the trawl-caught samples was similar to that of the fluke taken by the sport fishery. The age composition for the trawl-caught sample was determined for the years 1958 and 1959 (Figure 11) by eliminating the selected larger fish previously mentioned. The distribution illustrates that the sport fishery landed primarily fluke which were 1 or 2 years old. In 1958, 77 per cent of the catch was composed of these two age groups; in 1959, 90 per cent.

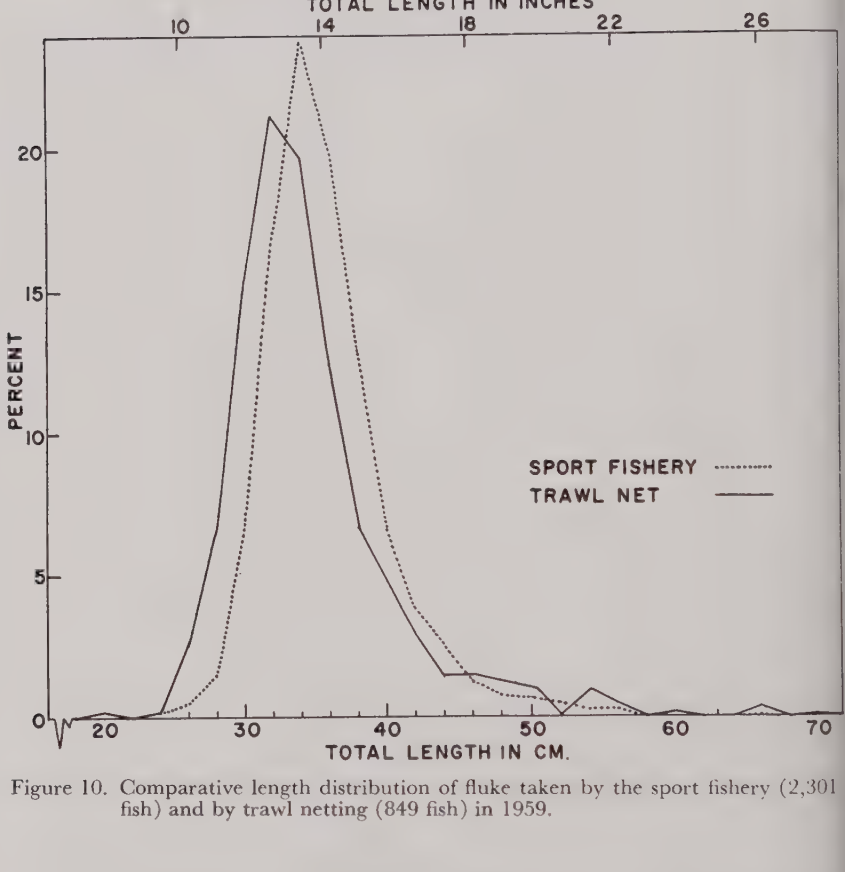
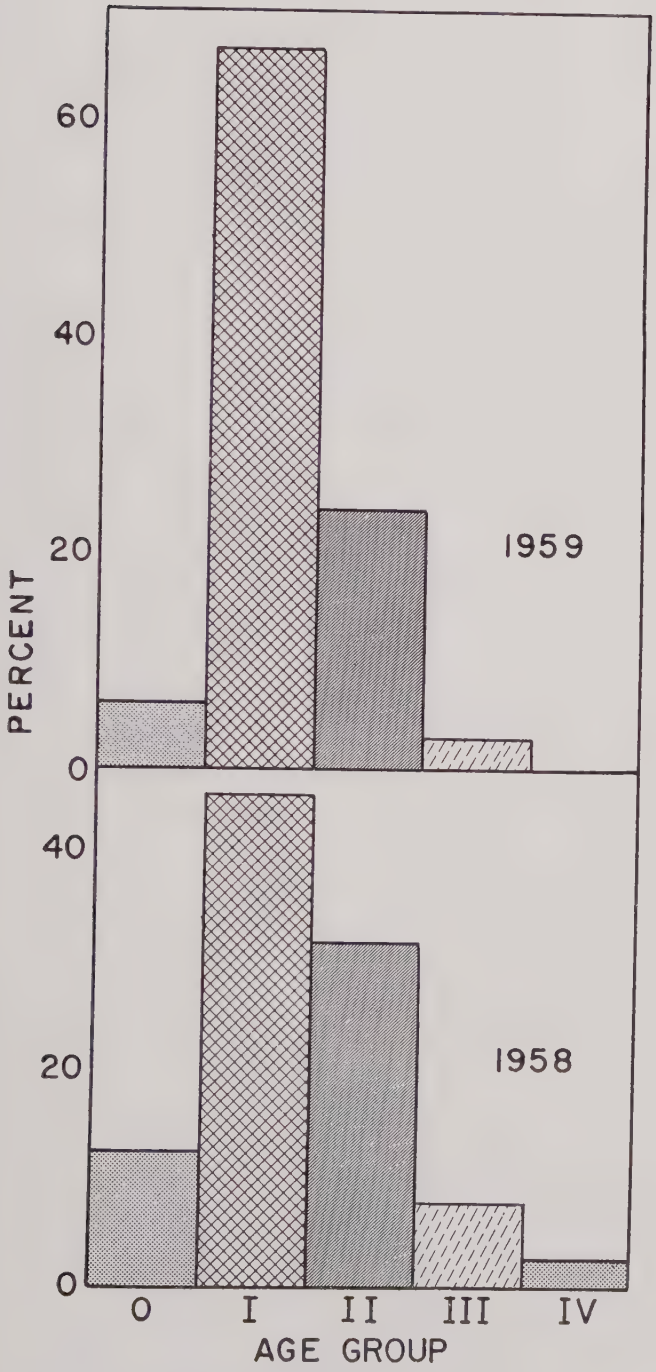


Figure 10. Comparative length distribution of fluke taken by the sport fishery (2,301 fish) and by trawl netting (849 fish) in 1959.

CONCLUSIONS

Age and growth of fluke from Great South Bay were determined by means of annular marks on the otolith. The data pertain chiefly to fish less than 4 years old. They do not represent a major portion of the life span of this species, for there have been few larger fish in the fish populations which enter Great South Bay. This study demonstrated that these larger fish were not present during 1958 and 1959, and other data, not included here, indicate that they were not present in any quantity in 1956 and 1957. Nevertheless, the data reveal that it requires but 1 year and 3 months of growth for fluke to reach a size at which they are available to, and are landed by, the sport fishery. They also reveal that fish in Age Groups I and II are still growing at a rate which adds an appreciable increment to their length each year. Age composition of the landings demonstrates the importance to the sport fishery of 1- and 2-year-old fish. Therefore, the great majority of the fluke taken by sport fishermen were still in the process of adding considerable growth increments. This



ure 11. Age composition of fluke taken by trawl netting in Great South Bay in 1958 (152 fish) and in 1959 (224 fish).

situation is certainly not advantageous to the sport fishermen, for the potentialities of growth, which adds weight as well as length, are lost.

The great percentage of 1- and 2-year-olds in the sport fishery catch places the sport fisherman in an unfortunate position. He is dependent almost entirely upon the success of spawning in the previous year. This is emphasized by further examination of Figure 11. In 1958, 45 per cent of the landings were 1-year-olds. In 1959, they comprised an even greater proportion, 66 per cent. There exists practically no buffer between spawning and capture by the sport fisherman. Therefore, his fishing success will fluctuate directly with the previous year's spawning success. This would not be the case if the fishermen were primarily landing 4-, 5-, and 6-year-old fish, for a failure in spawning in any one year would be buffered by three or more years of recruitment. It can be concluded that the sport fishery for fluke in Great South Bay will be subject to decided fluctuations in catch as long as it is so largely dependent upon 1- and 2-year-old fish.

LITERATURE CITED

Alperin, Irwin M. and J. C. Poole. 1956. Long Island's fluke. N. Y. S. Conservationist. 11(3): 16–17.

Clemens, Howard P. 1951. The growth of the burbot *Lota lota maculosa* (LeSueur) in Lake Erie. Trans. Amer. Fish. Soc. 80: 163–173.

Fitch, John E. 1951. Age composition of the southern California catch of Pacific mackerel 1939–40 through 1950–51. Calif. Bur. Mar. Fish. Bull. 83: 13–16.

Hildebrand, Samuel F. and W. C. Schroeder. 1928. Fishes of Chesapeake Bay. Bull. U. S. Bur. of Fish, Part I. 43: 165–167.

Moore, Emmeline. 1947. Studies on the marine resources of southern New England. VI. The sand flounder, *Lophopsetta aquosa* (Mitchill). Bull. Bingham Ocean. Coll. XI(3): 28–41.

Neville, William C., C. L. Dickinson and J. R. Westman. 1939. Miscellaneous species. In: A Biological Survey of the Salt Waters of Long Island, Part I. N. Y. S. Cons. Dept. : 134–138.

Pearson, John C. 1932. Winter trawl fishery off the Virginia and North Carolina coasts. Invest. Report, U. S. Bur. of Fish. 1(10): 24–25.

Westman, James R. 1946. Some studies on the life history and economics of the fluke. A report printed under sponsorship of the Islip Town Board, Islip, New York.

SEEDING HERBACEOUS PERENNIALS IN FOREST AREAS FOR GAME FOOD AND EROSION CONTROL

William L. Webb — Associate Professor of Forest Zoology, State University College of Forestry at Syracuse University

Earl F. Patric — Assistant Professor in Charge, Archer and Anna Huntington Wildlife Forest Station

ABSTRACT

The key to most wildlife habitat management in forests of the Northeast is management of vegetation so a larger proportion of the energy storage by plants is within reach of terrestrial animals. Following the opening of dense crown canopies by logging or thinning, improvement of habitat is often unsatisfactory in both qualitative and quantitative terms. Planting agricultural crop species in recently disturbed forest areas offers an opportunity to increase the variety and amount of vegetation available. Objectives of such plantings include provision of a supply of high-quality wildlife food, prevention or reduction of erosion in the disturbed area, and improvement of appearance in the area following the disturbance.

Forty species and varieties of plants were tested and 12 species were successfully established along recently abandoned haul roads and skid trails in the central Adirondacks. Combination plantings of clovers and grasses are not recommended because the less vigorous clovers are soon crowded out. Small additions of phosphate fertilizer improved stand density, height growth, and over-all success of legumes but had slight effect on grasses. Lime is not needed even on very acid soils. If seeding is done in early spring, soon after disturbance, no raking is needed. Medium red clover and mammoth red clover were seeded in good sites at 9 pounds per acre with 150 pounds of superphosphate per acre. These clover stands were heavily utilized by deer and other game. A mixture of four grass species seeded on steep slopes prevented erosion but did not provide much game food.

Each unit of forest land has a fixed capacity for annual production of plant tissue chiefly determined by soil, climate, and energy received from the sun. This plant production capacity, in turn, is an important factor which limits the production of wildlife. In forests of the Northeast the annual production of plants and animals is relatively low because of low levels of soil fertility and severe climatic factors. These limiting factors of soil and climate are generally not under the control of the wildlife manager, although he may attempt to modify the effects of climate with cover and to improve fertility with soil amendments.

In most forest areas the wildlife manager must manage the habitat by manipulation of the solar energy factor. In many areas the tree crown canopy is so dense that the great bulk of annual energy storage in plant tissues is in leaves, buds and twigs high above the ground or in wood under a thick coating of bark. The deer and grouse of these forests subsist on the small amount of energy that filters through the dense crown and which is stored by small trees, shrubs and herbs.

In these forests the key to most wildlife habitat management is to lower the zone of photosynthesis so energy stored by plants is within reach of terrestrial animals. This is done by logging or thinning timber

stands or by such accidental means as fire and windthrow. Such disturbances probably do not increase the total energy transformation or storage per acre, but merely move it nearer the ground and make it more available. Thus the disturbance creates better wildlife habitat in a quantitative sense because of improved availability.

This quantitative improvement is usually quite temporary. Many established herbs and shrubs, along with advance-growth trees and the residual trees left by the cutting operation, respond to opening up the crown. In a very few years the advance growth and the residual trees form such a dense overstory that production of vegetation near the ground may be even lower than before the disturbance.

In northeastern forests disturbance by logging and thinning may also create very slight qualitative changes in vegetation. Climax and subclimax plant species adapted to the soil and climate are generally able to reproduce and survive in the shade of mature stands. After the dominants are thinned or removed, a new species has little chance to invade the habitat because the advance growth quickly reestablishes the original stand in a younger form. Low-growing, light-requiring species may not even become established in the short interval. If they do become established, they may be quickly eliminated by the vigorous growth of climax species.

Thus disturbance of the forest creates only a temporary wildlife habitat improvement. The quantitative advantage is temporary because of rapid regrowth, and there may be little or no qualitative change in the stand. The wildlife manager must seek ways to increase the quantity and variety of plants which respond to changes in the crown canopy. One method for accomplishing this is planting nursery stock and seeding.

On the Archer and Anna Huntington Wildlife Forest[1] study of planting and seeding has been under way since 1940. Earliest investigations pertained to plantings of woody shrubs of more than 50 species. These were intended as seed-source plantings, i.e., small plantations established on selected sites to provide a source of seed when the surrounding forest stand was disturbed by cultural operations such as logging and thinning. The seed-source-planting technique and species used were described by Webb and Patric (1956).

Another phase of planting research on the Huntington Wildlife Forest has been a study of the feasibility of seeding herbaceous perennials (agricultural crop species) in recently logged and thinned stands. The objectives of these plantings are threefold:

1. To provide nutritious, palatable wildlife foods to supplement production of native species

[1] A property of the State University College of Forestry at Syracuse University, located in the Adirondack region, near Newcomb, and operated for the conduct of wildlife research.

2. To provide plant cover to check erosion and siltation on areas where the soil surface has been disturbed by logging equipment
3. To improve the appearance of recently disturbed areas so the public will not view such improvement work as unsightly

Only a few years ago it was not necessary to consider such plantings because horses used in logging served as a natural seed source. Clovers and timothy sprang up along logging roads and skid trails and often persisted for many years after logging was completed. Deer and grouse often concentrated along such travel lanes because of availability of high-quality foods at critical periods of the year. In today's logging the tractor has so nearly replaced the horse that such seeding does not occur. Logging roads and skid trails often remain as raw, ugly, unproductive tracks through the forest many years after the job is completed.

PLANTING SITES

Establishment of herbaceous plants in a forest area can be accomplished effectively because of the extensive soil disturbance caused by modern mechanized logging. Skid trails, haul roads, shoulders and cuts along truck roads, log-deck areas, turnouts and landings provide a considerable area of disturbed soil which may be seeded with a minimum of effort.

On the Huntington Wildlife Forest such areas have been seeded to a variety of species with considerable success. These plantings have produced wildlife food which has been heavily utilized, erosion has been minimized or eliminated from most areas, and appearance of logged areas has been considerably improved.

These planting areas have severe climatic and edaphic conditions. The growing season averages about 100 days. Many sites are partially shaded by residual trees in the adjacent stand. In many cases organic matter has been removed by logs and vehicles, exposing bare mineral soil which is subject to washing and excessive drying. Soils are very acid with pH readings varying from 3.6 to 5.5.

SEED DISTRIBUTION AND PLANTING

In all plantings seed was broadcast by hand or with a cyclone seeder. Rather extensive tests were made to determine the desirability of soil disturbance following seeding to insure the seed being covered by earth. Hand raking and dragging brush behind a vehicle were compared with seeding on soil not disturbed after seed distribution. It was found that where seeding was done immediately after logging, before the soil became compacted, no soil disturbance was needed to secure adequate germination and establishment. Although some improvement occurred where the soil was raked, it was not enough to justify the added expense. Where

planting must be done after soil has become compacted, some soil disturbance after seeding is desirable and economically justified.

Limited tests were made to determine the relative merits of spring versus fall as a time for sowing seed. The results suggest that spring planting should be done wherever possible. Several fall seedings were successful, however, and perhaps seeding at this time may be advisable on areas where logging is done in summer. Rodents and birds undoubtedly consume more seed in fall plantings.

PLANT SPECIES TESTED

Forty species of plants have been tested since 1951 as shown in the following list.

LEGUMES

*Medium red clover	*Trifolium pratense*
*Mammoth red clover	*Trifolium pratense* var. *perenne*
White Dutch clover	*Trifolium repens*
Wild white clover	*Trifolium repens* var. *sylvestre*
Kentish clover	*Trifolium repens* var. *sylvestre*
Ladino clover	*Trifolium repens* var. *latum*
*Dairyman's alsike clover	*Trifolium hybridum*
White-blossomed sweet clover	*Melilotus alba*
*Bird's-foot trefoil	*Lotus corniculatus*
Winter vetch	*Vicia villosa*
Crown vetch	*Corinilla varia*
Canada pea	*Pisum arvense*

GRASSES

*Redtop	*Agrostis alba*
*Reed canary grass	*Phalaris arundinacea*
*Orchard grass	*Dactylis glomerata*
Kentucky bluegrass	*Poa pratensis*
Rough-stalked meadow grass	*Poa trivialis*
Domestic ryegrass	*Lolium* (mixed spp.)
Perennial ryegrass	*Lolium perenne*
*Canadian brome grass	*Bromus inermis*
Southern brome grass	*Bromus inermis*
Switch grass	*Panicum virgatum*
Quackgrass	*Agropyron repens*
*Alta fescue	*Festuca arundinacea*
*Creeping red fescue	*Festuca rubra*
Illahee red fescue	*Festuca rubra*
*Chewings fescue	*Festuca rubra* var. *commutata*

GARDEN AND CROP SPECIES

*Rape (Dwarf Essex)	*Brassica napus*
Rutabaga (L. I. Improved)	*Brassica napus* var. *napobrassica*
Brussels sprouts (L. I. Improved)	*Brassica oleracea* var. *gemmifera*
Kohlrabi (White Vienna)	*Brassica oleracea* var. *gongylodes*
Broccoli (Green Sprouting)	*Brassica oleracea* var. *italica*
Kale (Dwarf Curled)	*Brassica oleracea* var. *acephala*
Turnip (Purple-top White Globe)	*Brassica campestris* var. *rapa*
Chard (Fordhook Giant)	*Beta vulgaris* var. *cicla*
Salsify (Mammoth Sandwich Island)	*Tragopogon porrifolius*
Buckwheat	*Fagopyrum sagittatus*

MISCELLANEOUS

Wild rue	*Ruta thalictrum*
Skunk cabbage	*Symplocarpus foetidus*
Scotch broom	*Cytisus scoparius*

Most of them were tested on plots located along haul roads in recently logged northern hardwood stands (Society of American Foresters, 1932). Test plots were 66 feet long and 22 feet wide. Most species were tested on six plots with random assignment of species to plots. Notes were kept on germination, growth, vigor, and evidence of use by animals for the first growing season. In following seasons records were kept of stand density, average height, and a rating of how well the seeding met the objectives of planting. The rating scale is given with Table 1. Of the 40 species tested, only 12 were given a high enough rating to be considered for further testing as indicated in the foregoing list.

Legumes

Four of the legumes tested proved to be good species for herbaceous plantings even on these highly acid soils without addition of lime. Most of the unsuccessful species germinated well and grew rapidly but displayed poor qualities of tolerance and persistence. Medium red clover and mammoth red clover were especially heavily browsed by deer. They remain green all year and provide highly palatable deer food in late fall and early spring when deer are largely limited to a woody browse diet. Alsike clover is nearly as good as these two varieties of red clover, but it does not grow quite so tall under these site conditions. Bird's-foot trefoil grows on surprisingly poor soil but requires considerable overhead light. Where it is subject to much shading it rapidly gives way to native vegetation. On sunny sites it persists for many years, forming a dense mat with good erosion-resistance qualities. However, there is little evidence that deer in this region find bird's-foot trefoil very palatable. In many cases both the red clovers were heavily grazed while the trefoil was only

lightly utilized. The latter does flower and fruit heavily each year and the seeds may be used by small animals.

Bird's-foot trefoil and medium red clover were given an extensive comparison on a series of 30 plots. Each species was assigned to 15 of the plots at random. The results clearly indicated that medium red clover was significantly better than bird's-foot trefoil in stand density, height and over-all rating. Moreover, the trefoil was used only lightly by deer while red clover was heavily utilized.

Grasses

Fifteen species or varieties of perennial grasses were tested; seven were successfully established under a variety of environmental conditions. These grasses vary in growth form from tall coarse species with broad leaves to short recumbent species with fine leaves. Reed canary grass, Canadian brome grass, orchard grass, redtop, and three of the fescues were very effective herbaceous plantings. Although none of these grasses was browsed by deer to any extent on any planted area, they did provide an effective plant cover for erosion control and greatly improved appearance.

Reed canary grass is the tallest of all the species tested, reaching heights of over 5 feet. It is very coarse and persistent, and in some cases it was aggressive enough to spread outside the areas planted. It seeds annually and turns brown in fall. This species seems to require more light than orchard grass, redtop, or the fescues. Canadian brome grass was eliminated from further trials because, although it was similar to reed canary grass in growth form, it was inferior to it in vigor and growth.

Orchard grass is a hardy, persistent plant, but not so aggressive as reed canary grass. It achieves heights of up to 3 feet and it seeds annually. The vertical stalks turn brown in fall, but the lower reclinate leaves remain partly green all winter. Although it may require slightly less light than canary grass, orchard grass is more susceptible to invasion of native vegetation. It is somewhat neater in appearance than the coarse canary grass.

Redtop is a short, fine-stemmed plant with a vertical growth habit. Although not an aggressive plant, it resists shading better than all other grasses tried. It starts rapidly, producing a dense stand of short, fine stems within a few weeks. Full height is only 1 to 2 feet. Redtop's exceptionally small seeds adhere to steep banks and crevices where larger seeds would be washed away before germination. Red top does not have the bulk and vigor of canary grass or orchard grass, nor does it have the neat appearance of the fescues. However, it has superior qualities for preventing erosion and improving appearance along narrow skid trails, haul roads and banks where shading may prevent establishment of other grasses.

Three of the four fescues tested were considered successful. Chewings fescue was the best variety used, and since all had about the same characteristics it was used in all further work. Chewings fescue is somewhat slow to establish, but once established it is very persistent. The fine, wiry blades form a mat near the ground surface which becomes an extremely effective erosion preventive. Its almost lawn-like growth gives roadsides and trails a very neat appearance. Insects seem attracted to this species, and such planted areas may serve as feeding grounds for young grouse and other insectivorous animals.

GARDEN AND CROP SPECIES

Only rape, of the 10 species in this category, was considered worth further testing. Attention was called to this species when it was noticed that rape was heavily browsed by deer when planted with bird's-foot trefoil (rape seed was a contaminant in some lots of trefoil seed). Rape under these climatic conditions is a "persistent annual" because the first season's growth is vegetative while the second season's growth is tall and spindly, topped by the flower. On the Huntington Wildlife Forest only a few plants produce viable seed in the second year, before the plant dies. Rape is used in our planting programs to provide food for deer in the first season to take grazing pressure from other planted species.

COMBINATION PLANTINGS

Any work with these species in a forest environment leads the investigator to wonder if combinations of several species might not satisfy objectives of the planting program better than any single species. A mixed stand of grasses and legumes, for example, might provide better wildlife food and erosion control than a pure stand. Also the soil and light requirements of the species are so variable that a combination would seem to offer better possibilities for achieving establishment of vegetation under all conditions.

Combination plantings were studied on the Huntington Wildlife Forest in two series of tests. In the first series, 60 plots were used with seeding assigned at random to 15 plots for each of the following:

Medium red clover
Medium red clover and grass
Bird's-foot trefoil
Bird's-foot trefoil and grass

In the second series, 11 combinations of seed were sown on replicated plots (number of replications variable). These combinations were:

Bird's-foot trefoil and perennial rye grass
Bird's-foot trefoil and creeping red fescue

Bird's-foot trefoil and reed canary grass
Bird's-foot trefoil and orchard grass
Bird's-foot trefoil and timothy
Bird's-foot trefoil and redtop
Bird's-foot trefoil, reed canary grass, orchard grass, Chewings fescue, and redtop
Medium red clover and bird's-foot trefoil
Medium red clover, reed canary grass, orchard grass, Chewings fescue, and redtop
Bird's-foot trefoil, medium red clover, reed canary grass, orchard grass, Chewings fescue, and redtop
Reed canary grass, orchard grass, Chewings fescue, and redtop

As a result of both series of tests it is certain that combination plantings of legumes with grasses cannot be recommended. In almost every case the species best adapted to the site conditions quickly crowded out the others, leaving an essentially pure stand. In most cases it was grass which crowded out the legume. Most of the combination planting sites were soon dominated by the grasses in the mixture, and, because grasses have little value for wildlife food production, legumes should be planted alone under most conditions.

The only desirable combination is the mixture of four grasses (reed canary grass, orchard grass, Chewings fescue, and redtop). This combination has highly desirable erosion-control and appearance qualities. Each of the species does best under slightly different site conditions, so that the desirable characteristics of each species are not masked by the others. Reed canary grass dominates the mixture in open areas and may germinate best on knolls and areas with a minimum of bare mineral soil exposed. Orchard grass responds best in moist, open sites. The fescue produces its sleek mat of green cover on sloping banks and level shaded areas where orchard grass does not survive. Redtop grows best on steep banks, the walls of washes, and other moist, shaded areas.

SOIL AMENDMENTS

Chemical analyses of soils of the Huntington Wildlife Forest indicated the difficulty of planting and suggested that soil amendments in the form of fertilizer and lime would pay dividends in securing growth of most agricultural crop species. Nitrogen and potassium levels are fairly high, but available phosphorus levels are very low. All soils are very acid with pH levels usually well below 5.0. An agronomist would recommend heavy liming (5 to 10 tons per acre) to decrease acidity and make phosphorus available.

In 1954 a series of 21 plots (each 66 by 22 feet) was established to

etermine response of bird's-foot trefoil to the following soil amendments hen applied at commonly recommended levels:

Ammonium nitrate
Muriate of potash
Commercial 10–10–10
Ground limestone
Commercial 0–20–20
Superphosphate

ach treatment was replicated on three plots and there were three control lots where no soil amendments were added. Assignment of treatments o plots was random.

There was no question about the outcome of the experiment, and esults were still apparent after five growing seasons. All plots treated vith fertilizers which contained phosphorus produced markedly superior tands of bird's-foot trefoil compared with those plots which were not reated with phosphate. Plantings treated with lime, ammonium nitrate, nd muriate of potash showed little or no effect and could hardly be listinguished from the control plantings which received no soil amendnents. Limited tests on other species of plants also suggested that any naterial containing phosphorus increased plant establishment, growth, nd survival.

The results of this test were so clear-cut that the next step was to letermine the effects of phosphate fertilizers on other plant species and letermine the best rate of application. Five rates of fertilization were ested on a series of 75 plots of the same size for seedings of five species or ombinations as follows:

Bird's-foot trefoil
Medium red clover
Mixed grasses (reed canary grass, orchard grass, Chewings fescue, and redtop)
Bird's-foot trefoil plus the four mixed grasses
Medium red clover plus the four mixed grasses

he phosphate application rates (in terms of 20 per cent superphosphate er acre) were: none (control), 75 pounds, 150 pounds, 300 pounds, and 00 pounds.

Results of this test were measured at the end of the first growing eason. Each plot was examined to determine the density of the plants urviving in terms of ground coverage, the average height of the plants, nd an over-all rating of the value of the planting. The rating was obained by estimating the extent to which the planting satisfied the objecves of the project, i. e., wildlife food, erosion control, and improved ppearance. The rating scale of five values is given in Table 1.

Table 1. Effect of Phosphate Fertilizer on Five Seedings of Herbaceous Perennials at the End of the First Growing Season *

Rate of Fertilization §	Seeding						
	Bird's-foot trefoil	Medium red clover	Mixed grasses †	Combination		Combination	
				Bird's-foot trefoil	Mixed grasses †	Medium red clover	Mixed grasses †
None (control)	36–3.7 (2.3)	54–3.8 (2.0)	80–6.5 (3.7)	34–3.3 (3.0)	60–6.3	54–4.7 (3.3)	80–8.8
75	80–5.8 (4.0)	70–5.0 (3.3)	70–7.2 (3.0)	36–5.0 (3.3)	80–7.0	46–5.3 (3.7)	74–7.8
150	64–5.5 (2.3)	66–5.3 (3.3)	84–8.5 (4.0)	56–6.3 (4.3)	86–8.3	56–5.8 (4.3)	84–7.7
300	76–5.5 (3.0)	76–5.7 (3.7)	86–8.2 (4.0)	54–6.3 (3.3)	84–8.5	44–4.3 (4.0)	80–7.7
500	70–5.5 (3.3)	86–5.8 (4.3)	100–8.2 (4.3)	30–2.3 (3.7)	86–8.2	50–4.8 (3.7)	76–6.8

* Figures represent averages for three plots for each seeding at each rate of fertilization. In each case: first figure is density as coverage in per cent; second is average height of stand in inches; figure in parentheses is over-all evaluation of stand.

Evaluation rating scale: 1 = poor or failure; 2 = fair; 3 = satisfactory; 4 = very good; 5 = excellent.

§ Pounds of 20 per cent superphosphate per acre.

† Equal amounts of reed canary grass, orchard grass, Chewings fescue, and redtop.

The effects of the several rates of fertilization on the five types of seeding are given in Table 1. Examination of these data and statistical analysis of them lead to the following conclusions. Use of phosphate fertilizer did not improve the performance of legumes when planted in combination with the grass mixture. Grasses soon dominated the stands and legumes were largely eliminated by the second growing season. Although grasses planted alone did not respond strongly to phosphate fertilizer in density or over-all rating, somewhat greater height growth may have resulted. Stands of grasses were good to very good regardless of whether fertilizer was applied. Both bird's-foot trefoil and medium red clover showed a marked response to phosphate fertilizer. The response was noted in increased density, increased height and an increase in over-all rating. Plots which were not fertilized were rated as fair, while even with the lowest fertilizer application they were rated as satisfactory to good. Increased intensity of fertilization did not result in a corresponding increase in plant response. We conclude that for legumes the application of 100 to 150 pounds of 20 per cent superphosphate per acre produces a near maximal increase in growth and vigor, while the grass mixture does almost equally well without application of any fertilizer. Legumes were benefited for several growing seasons.

PLANTING PROCEDURE

Several planting operations have been carried out on the Huntington Wildlife Forest to test the herbaceous planting technique as a large-scale operation. These pilot tests have indicated that such plantings are an economical method and produce significant amounts of wildlife food, prevent serious erosion under most conditions, and vastly improve the appearance of logged areas.

Medium red clover or mammoth red clover, at the rate of 24 pounds of seed per mile of road (9 pounds per acre), has been applied to the best planting sites where the ground is relatively level, moisture conditions are favorable and light is adequate. A mixture of four species of grass (equal parts of reed canary grass, orchard grass, Chewings fescue, and redtop) has been applied at the same rate to areas where erosion control is the major objective of planting and to dry, rocky, and shaded sites where clover would not grow well. Rape seed (at 5 pounds per acre) has been applied to the edges of roads, hummocks and odd areas, especially where a minimum of soil disturbance occurred. Rape grows well in such areas and provides considerable food for deer in the first growing season. It also relieves clover from some of the heavy deer grazing during the period of establishment. Superphosphate has been applied to clover plantings at a rate of about 150 pounds per acre (400 pounds per mile of road).

As a general "rule of thumb" it can be assumed that three-eighths of a mile of Adirondack woods road is equal to an acre of planting area.

Narrow skid trails have considerably less—perhaps half—this much planting area per unit of length. Seed and fertilizer should be distributed over the area to be planted as uniformly as possible. Careful advance planning is needed to avoid duplication and skipping of areas and to make efficient use of the time of the planting crew when there is a "maze" of roads and skid trails. All clover seed must be inoculated in advance as nitrogen-fixing bacteria are usually not abundant in forest soils.

The cost of the pilot applications over several hundred acres of logged areas has varied, depending chiefly on the extent that motorized vehicles could be used. Costs of labor, seed, and fertilizer ran between $45 and $65 per mile of haul road and averaged about $50 per mile ($17 to $24 per acre seeded). These seedings have been done mostly in early spring when planting success is highest, but this is also the time when muddy roads make it necessary to do more of the work by hand labor.

LITERATURE CITED

Society of American Foresters. 1932. Forest cover types of the eastern United States. Jour. Forestry. 30(4): 451–498.

Webb, William L. and Earl F. Patric. 1956. Seed-source plantings for habitat improvement in northeastern forests. Trans. N. E. Sect. Wildl. Soc. (mimeo.).

THE UPPER ST. LAWRENCE RIVER ICE FISHERY

William A. Pearce Conservation Biologist
New York State Conservation Department

ABSTRACT

A creel census during the winters of 1958–59 and 1959–60 provided much needed information on ice fishing in the upper 45 miles of the St. Lawrence River in New York State. Pike was the primary species fished for. Fishing pressure over the area as a whole was relatively light. A total of 1,479 anglers were observed and 1,280 of them were checked. They fished an average of four lines and, when checked, had caught 673 legal pike or one for each 8.1 hours fished. The ratio of male to female pike caught was 1:2.4. The ratio during the last month of season for the two winters was 1:2.3. Yellow perch was the only other species caught; fishing for them was usually incidental to fishing for pike. Some 63 per cent of the anglers had driven over 40 miles to reach their fishing grounds. There was no indication of overharvest of pike, and present regulations appear to be satisfactory in light of what is known about the over-all pike population in the area.

This study was undertaken to obtain much-needed information on ice fishing in the upper 45 miles of the St. Lawrence River on the New York side. With the advent of more leisure time, better roads and cars, insulated clothing and large pay checks, ice fishing in many areas of New York State has changed from a local meat fishery to an important sport fishery. The upper 45 miles of the St. Lawrence River with its many large, weedy bays and good pike habitat has been no exception.

In recent years the number of anglers from other areas that come to enjoy ice fishing for pike (*Esox lucius*) on the upper St. Lawrence River has reportedly increased greatly, much to the alarm of some local anglers. The district office of the Conservation Department has received complaints from local anglers and some summer residents that outsiders in large numbers were overharvesting the pike, especially large females toward the end of the season (March 1). Some local guides felt that the removal of pike in the wintertime was resulting in poorer pike fishing, particularly in the spring before the bass season opened, and was thus hurting their guiding business. Little actual information was available as to fishing pressure, anglers residence and magnitude of the catch for the ice fishery in the area. To obtain the necessary information, a creel census was undertaken in the winters of 1958–59 and 1959–60.

PROCEDURE

A complete census was impossible due to the large area involved and conflicting duties of the biologist taking the census. It was decided that checking would be done on at least one day each weekend throughout the season whenever possible and on weekdays when convenient. This schedule was followed except for one weekend in January 1959 when weather conditions made it impossible. Work was begun as soon as the ice became safe to walk on. The starting point was alternated between the lower and upper limits of the study area. A typical census day consisted of driving about 150 miles and walking about 10 to contact anglers.

The study area extended roughly from Cape Vincent to Chippewa Bay. The census was concentrated on the major fishing localities in this area, but nearly all accessible points along the river were also checked from time to time. As many anglers as possible were contacted, and those not actually contacted were counted. The biologist recorded the address of the angler, number and type of lines fished, hours fished, number and lengths of pike caught, sex of pike caught whenever it was possible to examine the gonads, and the number of yellow perch (*Perca flavescens*) caught. Individual records were kept for each locality checked. It was estimated that at least 50 per cent of the total angling was covered by creel census in the area during the two winters.

FINDINGS

During the 1958–59 season, ice fishermen were checked on 17 days from December 13 to February 28, including 14 Saturdays or Sundays (Table 1). The 668 anglers actually interviewed had fished 2,798 hours with an average of four lines each. Their total catch was 396 legal pike or one for every 7.1 hours of fishing. The average time fished by each angler when checked was 4.2 hours. Of 338 pike that were sexed, 110 were males and 228 females, a ratio of 1:2.1. The sex ratio varied little throughout the season; the proportion of females increased slightly during the last month, being 2.3 compared with 2.0 earlier. Female fish averaged 25.5 inches long and ranged from the minimum legal length (20 inches) to 36.0 inches. Males averaged 22.9 inches and ranged from 20.0 to 29.0 inches. It was not always possible to determine the sex of a fish without dissecting it; some females in poor condition appeared externally to be males.

The following winter the census was not started until January 7, 1960 due to lack of ice. It was continued to the end of February for a total of 14 days, including nine Saturdays or Sundays (Table 2). The 612 anglers actually contacted had fished 2,673 hours with an average of four lines each. They caught 277 legal pike, or one for every 9.6 hours fished. The average time fished by each angler when checked was 4.4 hours. Of the 175 pike that were sexed, 40 were males and 135 females, a ratio of 1:3.4. In the last month of the season the proportion of females caught decreased. Prior to February 1, the ratio was 14 males to 74 females (1:5.3); after that it was 26 males to 61 females (1:2.3). The male fish averaged 23.1 inches long and ranged from 20.0 to 29.0 inches. The females averaged 25.5 inches and ranged from 20 to 34.0 inches.

In all, 1,280 anglers had fished 5,471 hours with an average of four lines each when checked. They caught 673 legal pike, an average of one per 8.1 hours of fishing. Very few daily limit catches of five pike per angler were recorded. Of the 513 fish sexed, 150 were males and 363 females, a ratio of 1:2.4. The ratio during the last month of season

TABLE 1. CREEL CENSUS DATA FOR ICE FISHERMEN CHECKED ON THE UPPER ST. LAWRENCE RIVER *, 1958-59

Date	Anglers checked	Lines fished	Hours fished	Legal pike caught			Sex ratio §
				Male	Female	Not sexed	
December 13	20	81	90	5	22	0	1 : 4.4
20	21	108	92	3	12	3	1 : 4.0
21	14	70	53	5	5	1	1 : 1.0
27	30	149	136	5	22	17	1 : 4.4
January 3	67	302	264	27	34	0	1 : 1.3
4	58	264	258	15	36	4	1 : 2.4
10	39	173	172	4	9	1	1 : 2.3
11	63	270	216	10	5	1	2 : 1.0
17	9	45	17	1	1	0	1 : 1.0
29	7	7	18	0	2	0	0 : 2.0
February 1	32	137	87	3	0	8	3 : 0.0
4	8	49	6	0	0	0	0 : 0.0
8	50	179	197	2	11	1	1 : 5.5
14	88	441	486	19	47	17	1 : 2.5
21	45	170	171	2	7	0	1 : 3.5
27	7	23	25	0	0	1	0 : 0.0
28	110	289	510	9	15	4	1 : 1.7
Total.....	668	2,757	2,798	110	228	58	1 : 2.1

* Area from Cape Vincent to Chippewa Bay.
§ Males to females.

was 61 males to 141 females (1:2.3) as compared with 89 males to 222 females (1:2.5) before February 1. Female pike made up about 70 per cent of the legal catch, but the data did not support the contention that they were much more readily caught during the latter part of the season than prior to that time. A few sub-legal pike were reportedly caught, but were not included in the catch records. Very likely the majority of the sub-legal pike caught were males, but they were not available to be checked.

Most anglers interviewed were primarily pike fishermen, but nearly all fished a hand line or pole for yellow perch. In 1958–59 a total of 2,399 perch were checked as compared with 2,338 the second year.

Besides the 1,280 anglers actually contacted another 199 fishermen were observed, but they were not checked due to lack of time. Probably the statistics for the anglers checked can be applied to those not checked. Fishing pressure was very light on the eight weekdays when censuses were made.

In the 1958–59 season most anglers (71 per cent) drove over 40 miles one way to fish; the following year the proportion was 55 per cent. Many, some of whom were from neighboring states, drove well over 100 miles. The distribution for the two years, according to three distance categories, is given in Table 3.

Table 2. Creel Census Data for Ice Fishermen Checked on the Upper St Lawrence River *, 1959–60

Date	Anglers checked	Lines fished	Hours fished	Legal pike caught			Sex ratio §
				Male	Female	Not sexed	
January 7	16	97	106	0	3	9	0 : 3.0
9	65	311	386	3	17	31	1 : 5.7
10	22	123	90	0	4	13	0 : 4.0
12	16	72	85	1	2	7	1 : 2.0
16	50	187	145	2	12	3	1 : 6.0
18	14	68	39	0	5	1	0 : 5.0
23	100	329	240	4	15	2	1 : 3.8
29	7	25	23	0	1	0	0 : 1.0
31	110	465	473	4	15	15	1 : 3.8
February 6	55	224	285	8	25	0	1 : 3.1
13	83	338	407	15	24	9	1 : 1.6
17	8	29	36	1	1	1	1 : 1.0
21	13	67	71	0	3	1	0 : 3.0
28	53	233	287	2	8	10	1 : 4.0
Total.....	612	2,568	2,673	40	135	102	1 : 3.4

* Area from Cape Vincent to Chippewa Bay.
§ Males to females.

DISCUSSION

The study area encompassed the upper 45 miles of the St. Lawrence River within New York State. It included the famous Thousand Island section as well as many weedy bays with excellent pike habitat. Some of the bays were accessible by road, but most of the area was practically inaccessible in the winter time and was fished little or none during the census period.

Fishing pressure depended considerably on weather conditions. The days that anglers were checked were biased. When possible, work was done on the days with the best weather conditions in order to contact the largest number of anglers. If conditions were suitable, anglers drove their cars out on the ice. However, winter conditions were often quite severe and toward the end of the season heavy snow usually prevented driving on the ice. Deep snow also made walking difficult and further restricted the accessible fishing area.

Most anglers came from a considerable distance. However, most of the State's population lived a considerable distance away. The local countryside has always been sparsely populated. Watertown, with about 33,000 inhabitants and located about 40 miles south of the farthest limit of the study area, was the largest nearby city. Local residents fished little when weather conditions were poor, as they were in 1958–59. Many of the ardent anglers who drove considerable distances regardless of the weather fished two or three days. Most of them stayed at local hotels and undoubtedly aided the economy of the community.

TABLE 3. DISTANCES TRAVELED BY ICE FISHERMEN CHECKED ON THE UPPER ST. LAWRENCE RIVER * DURING THE WINTERS OF 1958–59 AND 1959–60

Fishermen	Miles traveled (one way)		
	0–20	21–40§	Over 40
958–59			
Number	114	79	475
Per cent	17	12	71
959–60			
Number	182	100	354
Per cent	29	16	55
otal			
Number	296	179	829
Per cent	23	14	63

* Area from Cape Vincent to Chippewa Bay.
§ Includes fishermen from Watertown; also includes 24 who were not contacted but whose addresses were obtained from friends.

By far the majority of people contacted were out to enjoy themselves nd the catch was secondary to breaking up the monotony of winter. Many were farmers or other persons who could not take time to fish during the rest of the year but were able to get away in the winter.

Minnows were the standard bait. The condition and size of the bait appeared to influence the catch. It was often impossible to buy good bait locally, and many outsiders soon learned to bring their own. A very few anglers used jigging spoons, but most set out the legal limit of five tip-ups and fished a pole for perch.

Prior to 1951 anglers were permitted to use 15 tip-ups; since then he legal limit has been five. Besides the tip-ups, each angler is allowed wo hand lines. Possibly the large catches of pike reportedly caught in he past were partly a result of using 15 tip-ups. There was no indication of overharvest under the present limit on lines. Except for an occasional lay when word spread that fish were biting in a particular area, there was little crowding with anglers limited to five tip-ups. However, if each ngler had been allowed 15 tip-ups, a few large parties of fishermen could ave practically monopolized the fishing in some of the favorite smaller ays. The present limit on lines used appeared to be satisfactory and robably helped bring the fishery more into the realm of sport fishing.

The data obtained from the ice-fishing creel census are by no means onsidered sufficient to provide an over-all solution to such a complex roblem as the proper management of the pike population in the St. awrence River. Ice fishing is but one of many facets of the dynamics f the pike population as a whole. Statistics on pike fishing during the est of the year are needed to round out the picture; such data were

lacking at the time of the study and would have been much more difficult to obtain. It is not known if there are separate pike populations in the various bay areas along the main shoreline and among the thousands of islands in the upper section of the river. If there are separate populations, then certain bays may be overfished in the winter time. On the other hand, if the pike move freely from one area to another and are more or less one large homogeneous population, it appears very unlikely that ice fishing at the present rate of harvest is detrimental. Ice fishing is currently restricted by accessibility to a relatively insignificant proportion of the entire pike habitat involved.

A number of other questions to be considered revolve around whether or not a large pike population is desirable. Would a large pike population reduce the number of black bass (*Micropterus dolomieu*) which is considered the number one game fish in the area? Would a large pike population be harmful by reducing the number of pan fish which probably provide as much enjoyment to the novice and children as the game fish do to the ardent angler? Would a large pike population benefit the pan fish by preventing an overabundant, stunted condition and at the same time benefit the bass by limiting competition from pan fish? If the pike population were smaller would its prized cousin, the muskalonge (*Esox masquinongy*), prosper better and become much more abundant? Would summer fishermen catch more pike if ice fishing were discontinued? What is the actual proportion of males to females in the pike population of the study area?

Although these questions were not answered by a simple ice fishing census, the study did provide answers to the primary questions it set out to solve. Where did the fishermen come from? How many fish did they catch? How much fishing pressure was there? Were more female than male pike caught, and were female pike caught in much larger proportions towards the end of the season than earlier? The data gathered have also helped Department biologists evaluate present regulations that affect this fishery.

CONCLUSIONS

There was no indication of an overharvest of pike, and the proportion of females caught did not increase much toward the end of the season. Although ice fishing pressure has undoubtedly increased in recent years as have other forms of angling, it was light over the study area as a whole. Most of the area was inaccessible to anglers in the winter. More than 60 per cent of the fishermen lived a considerable distance from the area where they fished. Ice fishing is not now a primarily local fishery as was probably the case a number of years ago. In light of what is known about the pike population, the regulations that were in effect during the study appear to be satisfactory.

WATERFOWL STOCKING IN NEW YORK[1]

Donald D. Foley — Conservation Biologist, New York State Conservation Department

Dirck Benson — Conservation Biologist, New York State Conservation Department

Lee W. DeGraff — Conservation Biologist, New York State Conservation Department

Earl R. Holm — Superintendent of Game Farms, New York State Conservation Department

ABSTRACT

Evidence indicates that most of the present breeding population of mallards in New York is the product of stocking since 1934. Stocking from 1934 to 1942 was to a large degree experimental and involved ducklings of three ages in addition to adults; 5-week-old birds gave the best results. From 1946 to 1952 mallards were stocked in larger groups and more for the gun than before. Band returns showed that 10.3 per cent of the adults released and 13.3 of the ducklings were taken by hunters. Mallard rearing and stocking was terminated following the 1952 season. Since then stocking experiments with a number of other species have been carried on.

Early records indicate that a few mallards once nested in the Erie-Ontario lowland of New York and possibly in the Lake Champlain region. Prior to 1900 this stock was all but eliminated by spring shooting and possibly overshooting in general. Since 1900, as well as to some extent before, semidomestic mallards have been reared on game farms and shooting preserves.[2] In addition, mallards were raised by duck clubs and individuals for use as live decoys. Parks and zoos also held small flocks. Some of these may have escaped and produced broods, but there is no evidence that these mallards were migratory. In fact, the U. S. Bureau of Biological Survey considered that game farm mallards were nonmigratory (Lincoln, 1934). Many had become so sedentary they could not or would not fly. In 1934, when the Conservation Department embarked on a stocking program, no wild mallards were definitely known to breed in the State.

HISTORY AND ORIGIN OF THE NEW YORK STRAIN MALLARD

A good-flying strain of mallard had been acquired at the Sherburne Game Farm in the early 1920's. Many of these nested in the valley along the Chenango River and afforded a limited amount of local shooting in the fall. These birds wintered on the spring-fed ponds on the farm. Some of the breeders were penned and their eggs were hatched under domestic hens. The ducklings were reared much the same as pheasants.

In 1934, a flock of wild-trapped mallards was obtained from Wisconsin. These were interbred with selected birds from the Sherburne

[1] A contribution (in part) of Federal Aid in Fish and Wildlife Restoration Project W-39-R.

[2] In 1959 there were 81 licensed duck shooting preserves, both commercial and private, in New York.

flock with two objectives: (1) to produce a strain that would be naturally migratory; and (2) to develop a flock that would be comparable to wild birds in size, color and body conformation. In an effort to accelerate the program, some mallards were purchased from private game farms, and others were received as gifts. These were rapidly discarded because they were overweight and off-color and many refused to fly.

MALLARD STOCKING 1934–1942

By 1942, which can be considered the end of the first stage of the program, over 8,000 mallards of the New York strain had been released. To follow its success or failure, field surveys were made to determine the immediate fate of the released birds and the degree to which they returned to breed the following year. Analysis of band returns was also used as a tool for estimating success.

Release of Breeders

Breeders intended for release were held over winter with one wing clipped. Pulling these clipped primaries just prior to crating for shipment to the release site was found most satisfactory, and shipment during the period from April 10 to 20 proved best for average New York conditions. The dates were varied to fit northern and southern, and high and low, sites.

Pairs of breeders were released in the spring, usually three or more at each site. All were banded. The sites used ranged from herbaceous marsh to wooded swamp, and surveys were conducted to sample all these types of habitat.

During the three years, 1939 through 1941, a total of 126 pairs were released on 10 areas and were checked about every two weeks. Some 77 per cent of these birds were known to have remained and set up territories for the breeding season. The other 23 per cent represented birds that were killed, birds that left the area as soon as they could fly, and others for which no inkling of their ultimate fate was recorded. As nearly as could be determined all that stayed and survived attempted to nest. Most pairs started to nest soon after release and their clutches hatched in mid-June, but a few delayed nesting for 2 to 4 weeks. Of 36 observed nests of released birds, 22 were broken up or deserted. Some 41 per cent of the released pairs eventually brought off broods. Exclusive of the original loss (23 per cent), it appeared that this mallard stock did about as well as the native black ducks and wood ducks on the same areas. It should be noted, however, that the average number of young reared was 4.0 compared with about 5.0 for established stock in later years.

Release of Ducklings

In the summer as young became available from the game farms, releases of ducklings were made, some at 3 weeks of age, some at 5 weeks

nd some at 7 weeks. The number liberated at each site ranged from 0 to 30, but was usually 10 to 15. All were banded. During the years 937 to 1941 ducklings were released on 10 areas[3] and were checked early every week until they could fly. This occurred at the age of 9 to 0 weeks for the birds released at 3 weeks of age, 10 weeks for those re-ased at 5 weeks, and 10 to 11 weeks for those released at 7 weeks.)bserved survival at flight age is shown in Table 1.

Losses of released ducklings resulted occasionally from overheating n the crates; this was most frequent among the 7-week-old birds. Cold

'ABLE 1. OBSERVED SURVIVAL TO FLIGHT AGE OF MALLARD DUCKLINGS RELEASED AT DIFFERENT AGES

Year	Number released	Survival to flight age		Number of areas used *
		Number	Per cent	
3-week-old stock				
938	40	14	35.0	4
939	85	42	49.4	4
940	45	13	28.9	2
941	40	13	32.5	2
Subtotal	210	82	39.0	..
5-week-old stock				
937	10	3	30.0	1
938	30	17	56.7	3
939	79	43	54.4	4
940	60	40	66.7	4
941	220	103	46.8	7
Subtotal	399	206	51.6	..
7-week-old stock				
937	10	7	70.0	1
938	10	7	70.0	1
939	60	46	76.7	2
940	52	42	80.8	3
941	70	36	51.4	3
Subtotal	202	138	68.3	..

* A total of 10 different areas were used: 8 for 3-week-old stock; 10 for 5-week-old stock; and 5 for 7-week-old stock. All the latter were also used for 3-week-old stock.

[3] One area, Vischers Ferry in Saratoga County, comprised six ponds that to a large degree were environmentally different.

wind and rain caused losses most often among the 3-week-olds. Pre dation took its toll of all three ages, but more kills were located among those released as 3-week-olds than among the others. In several instance released groups disappeared entirely with no signs or subsequent banc records to indicate any survival.

Return Following Migration

Some areas received repeated releases of breeders, others of duck lings, without returning stock being observed the following spring. O other areas, liberated stock (identified by bands) returned as breedin birds following both breeder and duckling releases. The scope of th tendency to return was demonstrated better by the second-year and sub sequent band returns.

Tabulation of indirect (after they had once migrated) recoveries o banded birds showed no significant difference in distribution betwee the ducklings and adults (Table 2). Some 25 per cent were reporte within 25 miles of the original release point and 70 per cent were take within New York State. The bulk of the out-of-state indirect recoveri were from Chesapeake Bay and other wintering areas to the south. Thes data are considered as definitely showing that the released mallards tend to establish breeding territories on or in the vicinity of the area of releas where they first had freedom of flight and that they tended to select th same wintering areas that were used by the native black ducks.

Value of Stock Released at Different Ages

Since no difference in homing instinct was demonstrated betwee ducklings and adults, the best age of stock for release boiled down t economics. If accumulated recoveries are used as a guide, the 5- an 7-week-old birds and the adults provided nearly equal rates of recover the 3-week-olds somewhat less. Since the adults, having been held ov winter, were more costly than the ducklings, the lack of greater retur indicated the ducklings to be more economical. The 5-week-olds wer

Table 2. Accumulated Recoveries from Game Farm Mallards Banded an Released from 1936 through 1940*

Age at release	Number released	Recoveries	
		Number	Per cent
3 weeks	886	61	6.9
5 weeks	1,156	110	9.5
7 weeks	989	102	10.3
Adult§	3,342	329	9.8

* After Mason (1947).
§ Released during spring.

favored over the 7-week-olds because the slightly greater return for the latter did not compensate for the higher cost of holding them 2 weeks longer.

One factor developed in the study that is very difficult to evaluate. While field surveys strongly indicated that the 3- and 5-week-old birds became much wilder and blended more with native flocks of black ducks than did the 7-week-olds and adults, the younger stock were more vulnerable to the gunner the first fall. Among the former 86.7 and 84.2 per cent, respectively, of all band returns were first-year recoveries, while among the others the proportions were 78.2 and 75.9 per cent, respectively (Mason, 1947). A partial reason might be that the older the bird when released, the more sedentary its habits and, hence, the less its chance of being taken by hunters the first year.

Another factor of interest in these studies is the indication that after initial losses, the released birds were very nearly on a par with wild birds, especially the 3- and 5-week-old stock. If the band loss[4] among these not-fully-developed ducks is accounted for and the losses from the time of release until they could fly are included, it appears that the remaining birds which were probably still carrying bands provided accumulated recoveries of about 20 per cent. This is about the same return that was being obtained from black ducks at that time.

MALLARD STOCKING 1946–1952

During this period mallards were stocked in larger groups. These large-lot releases may be said to have been made more for the gun than those just discussed, yet generally the birds were put out on good quality sites with the idea of establishing breeding populations. However, these areas were mostly ones that were heavily gunned, and the first-year band returns were therefore very heavy. Behind this lies the fact that many of these birds were either reared by game clubs or released in cooperation with them. In contrast, the earlier liberations were all Department-reared stock put out in lesser numbers on many small areas which were not as heavily hunted and which were often under Department control.

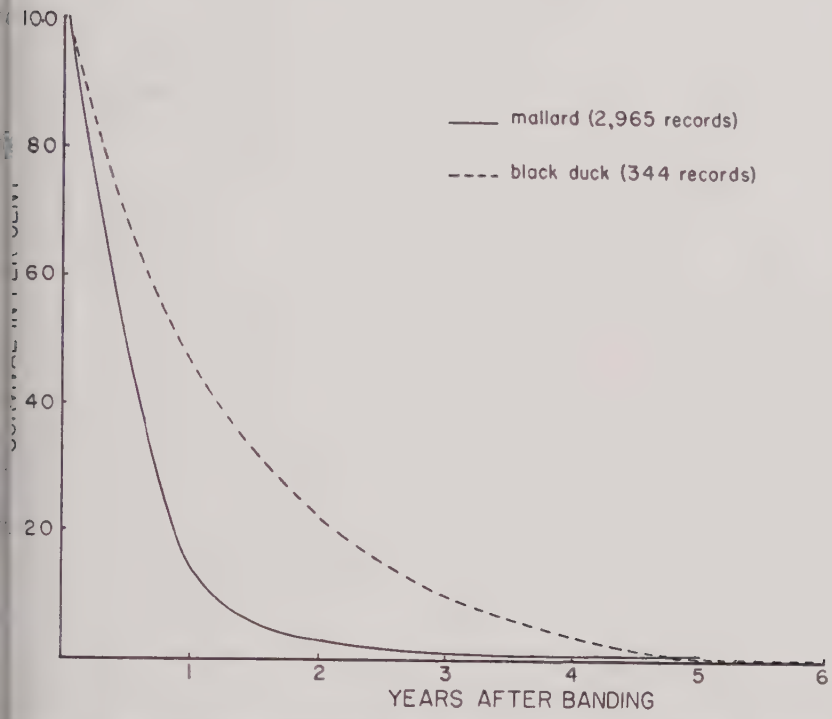
A total of 23,147 artificially propagated mallards were released from which 2,965 recoveries, or 12.8 per cent, had been received by late 1959. Most of these (11.0 per cent) occurred the first fall after release and largely represented hunting mortality. This harvest was made primarily on the areas of release or on areas in the near vicinity. In this last respect these released mallards did not differ greatly from wild stock, but their first-year mortality was higher. The rates of survival for released mallard

[4] Tests were made at the game farms by holding banded ducklings of each age until they were 10 weeks old. Of those banded at 3 weeks 12.5 per cent lost their bands; of those banded at 5 weeks, 10.3 per cent; of those banded at 7 weeks, 3.5 per cent.

Table 3. Artificially Propagated Mallards Banded and Released from 1946 through 1954*

Year	Number released	Recoveries																			
		1946		1947		1948		1949		1950		1951		1952		1953		1954		Total	
		Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent
1946...	1,045	131	12.5	9	0.9	4	0.4	...	...	2	0.2	2	0.2	...	...	...	...	...	...	148	14.2
1947...	2,203	...	...	250	11.3	28	1.3	19	0.9	3	0.1	3	0.1	...	...	...	...	...	...	303	13.8
1948...	2,285	...	...	...	...	403	17.6	48	2.1	5	0.2	2	0.1	3	0.1	...	...	...	...	461	20.2
1949...	1,947	...	...	...	...	...	...	249	12.8	33	1.7	11	0.6	5	0.3	...	...	...	...	298	15.3
1950...	5,228	...	...	...	...	...	...	...	...	582	11.1	105	2.0	20	0.4	2	tr	3	0.1	712	13.6
1951...	4,551	...	...	...	...	...	...	...	...	...	...	538	11.8	81	1.8	4	0.1	1	tr	624	13.7
1952...	5,888	...	...	...	...	...	...	...	...	...	...	...	...	396	6.7	18	0.3	5	0.1	419	7.1
Total..	23,147	131	...	259	...	435	...	316	...	625	...	661	...	505	...	24	...	9	...	2,965	12.8

* While all ages of stock are lumped together, 19,423 were ducklings and most of them were released at 5 weeks of age (see Table 5).



igure 1. Rates of survival, as derived from band recoveries, for game farm mallards (adults and ducklings combined) released 1946–1952 and for wild black ducks trapped at Perch Lake 1953–1954.

ock (ducklings and adults combined) and for wild black ducks are com-ared in Figure 1.

While the average first-year recovery was 11.0 per cent, two years aried widely from this (Table 3). In 1948 the proportion rose to 17.6 er cent and in 1952 it dropped to 6.7 per cent. The reasons for these ariations probably involved several factors including hunting pressure n the release area, weather and migration, and the opening date of the ason. In 1948 a higher proportion of the releases were made on the avily hunted Hudson River marshes, a warm fall favored a leisurely or tarded migration south, and the season opened October 15. All these ctors would favor a heavy harvest of released mallard stock. In 1952, n the contrary, most releases were made on lightly hunted water units, severe summer drought probably resulted in low survival of 5-week-old ock, and the season did not open until October 25 by which time many rds had migrated.

OMPARISON OF ADULTS AND DUCKLINGS

Of the total recoveries for both adults and ducklings, the propor-ons that were made the first year are given in Table 4. For each group

Table 4. Total Reported Recoveries of Stocked Game Farm Mallards and Proportion Reported for the First Year after Release

Recoveries	1946	1947	1948	1949	1950	1951	1952	Total
Adult								
Total.....	6	50	.....	60	29	140	97	382
First year								
Number.....	4	45	.....	45	17	128	89	328
Per cent.....	66.7	90.0	.....	75.0	58.6	91.4	91.8	85.9
Duckling								
Total.....	142	253	461	238	683	484	332	2,583
First year								
Number.....	127	205	403	204	565	410	307	2,221
Per cent.....	89.4	81.0	87.4	85.7	82.7	84.7	92.5	86.0

the proportion was approximately 86.0 per cent, largely representing hunting season losses. The variability of the data for adults was likely due to the smaller numbers involved.

Table 5 shows comparative rates of recovery during the years of record for both adults and ducklings. The over-all recovery of 10.3 per cent for adults as compared with 13.3 per cent for ducklings indicates a slightly higher vulnerability of young birds. However, if their progeny are added in, the contribution to the hunters' bag by the adult birds released may have been substantially more, bird for bird. Various factors contribute to the extreme annual differences recorded. Some of these have been outlined in this paper; the others we must leave to the reader's imagination.

Comparison of New York Strain Mallards with Wild Stock

As a sidelight on the whole problem of the release, survival and establishment of game farm mallards, a study by Foley (1954a, 1954b) in 1952 provided some comparisons between stock from various sources. Mallard ducklings of the standard "New York strain" were released on selected small marshes together with wild mallards obtained as eggs or day-old young that spring from the Delta Waterfowl Research Station (Manitoba). In addition, releases of so-called "crosses", progeny of matings of the New York and Delta stock, were also made.

Of 115 birds of each type released on the same areas, between 7 and 75 per cent of each survived to the age of flight. The chief difference noted among the three groups was the earlier age at which the pure Canadian birds were seen to fly. They took to the air a week to 10 days sooner than the others, and on or before the 9th week of age 77 per cent

TABLE 5. RECOVERY PATTERN FOR STOCKED GAME FARM MALLARDS RELEASED IN NEW YORK

Year	Number released	Item	Recoveries 1946	1947	1948	1949	1950	1951	1952	1953	1954	Total
Adult												
1946	* 7	Number	4	1				1				6
		Per cent	57.1	14.3				14.3				85.7
1947	331	Number		45	4	1						50
		Per cent		13.6	1.2	0.3						15.1
1948	46	Number										
		Per cent										
1949	343	Number				45	10	3	2			60
		Per cent				13.1	2.9	0.9	0.6			17.5
1950	284	Number					17	11	1			29
		Per cent					6.0	3.9	0.3			10.2
1951	1,507	Number						128	12			140
		Per cent						8.5	0.8			9.3
1952	1,206	Number							89	7	1	97
		Per cent							7.3	0.6	0.1	8.0
Total	3,724	Number	4	46	4	46	27	143	104	7	1	382
		Per cent										10.3
Duckling												
1946	1,038	Number	127	8	4		2	1				142
		Per cent	12.2	0.8	0.4		0.2	0.1				13.7
1947	1,872	Number		205	24	18	3	3				253
		Per cent		11.0	1.3	1.0	0.1	0.1				13.5
1948	2,238	Number			403	48	5	2	3			461
		Per cent			18.0	2.2	0.2	0.1	0.1			20.6
1949	1,604	Number				204	23	8	3			238
		Per cent				12.7	1.4	0.5	0.2			14.8
1950	4,944	Number					565	94	19	2	3	683
		Per cent					11.4	1.9	0.4	tr	0.1	13.8
1951	3,044	Number						410	69	4	1	484
		Per cent						13.5	2.3	0.1	tr	15.9
1952	4,682	Number							307	11	4	322
		Per cent							6.6	0.2	0.1	6.9
Total	19,423	Number	127	213	431	270	598	518	401	17	8	2,583
		Per cent										13.3

* This represents all the available information regarding adults released in 1946. It is included for the record and the percentages should be viewed with reservations.

were flying, while for the New York mallard the comparative figure was 42 per cent.

First-year band recovery was 4.2 per cent for the New York strain compared with 5.7 for the Canadian birds, which may not be significant. However, the degree of return to the site of release the following spring was 5.1 per cent of the calculated survivors for the New York strain and 6.3 per cent for those of the Canadian birds.

Based on all data, therefore, plus their more secretive habits as noticed by the various field workers, the ducklings of the Canadian stock were considered to be superior with respect to initial survival and even possible establishment although they did wander farther afield the first fall after release.

INFLUENCE OF HABITAT

While the data obtained do not lend themselves well to statistical analysis, the initial survival of released birds, both adults and ducklings, and the incidence of returning stock the following spring suggest that the habitat in which they were liberated was important. In both cases marsh areas in contrast to wooded swamp areas, and open marsh in contrast to dense unbroken marsh, were favored. Newly flooded woodland also seemed favored. Adirondack-type bogs and marshes seemed unfavorable. In general the richer the marsh type, the more favored.

PRESENT OUTLOOK ON MALLARD STOCKING

With the releases in 1952 the State's mallard rearing and stocking program ceased. There were several reasons for this, among them being that by then the mallard had become well established in most regions of the State and it was thought that further pump-priming would not increase the breeding population appreciably. Also, while there was a fairly good first-year recovery rate on these birds, there was apparently little survival beyond the first few years. Even with a first-year recovery rate of 11.0 per cent and a total recovery of 12.8 per cent, there was little actual improvement of duck hunting in general. Also, studies of the possibilities of establishing breeding populations of various other species through stocking were begun at this time.

At present mallards are breeding in nearly every county in the State. The densest populations occur in the better marshes of the Erie-Ontario lowland and the numbers taper off in the less fertile marshes. Few mallards are observed in the Adirondacks and relatively few in the Hudson Valley and Southern Tier regions. In recent years both breeding pair counts and brood records have suggested that mallards outnumber black ducks in the western half of the State but that the reverse is true in the Champlain and Hudson Valleys (Benson and Foley, 1956).

There are two schools of thought regarding the source of the present mallard breeding population in New York. One view is that the State's

stocking program was solely responsible. The other is that stocking was at least partly responsible, but that, during the period of stocking, the mallard had begun a natural eastward expansion of its breeding range and that this also was involved.

There can be no doubt that stocking was successful. Banding records demonstrate that game farm birds, both adults and ducklings, returned following migration to the sites where they had been released and that many bred and produced ducklings. Yet it is also clear that, at the same time, the mallard was increasing in abundance across Wisconsin, Michigan, Indiana, Ohio and southern Ontario and into northwestern New York and New England. It seems reasonable to presume that this natural expansion augmented the results of stocking. Whether comparable establishment of the mallard as a breeding species in New York could have been achieved if this had not occurred cannot now be determined.

STOCKING OTHER SPECIES

Following the initial stocking of certain other waterfowl species in New York in 1952, as reported by Foley (1954b), the establishment of one breeding colony of redheads on the Montezuma National Wildlife Refuge was virtually proven. It was "virtually" proven only because none of the returning stock was subsequently retrapped during the breeding season, although there is very good circumstantial evidence that the birds which returned to breed were of the original group released. Also, no redheads had been known to breed at this particular site in over 11 years, and never at the density recorded in 1953. Redheads have continued to breed there each year since, even in the face of adverse conditions such as drainage, fish-poisoning operations, and nesting studies by students.

The ducklings released in 1952 included 72 pintails, 50 redheads, 20 canvasbacks, 10 blue-winged teal and 10 shovellers, and up to 1957 no others of these species (except for an escape) were liberated. In that year, after certain rearing problems had been solved, 260 5-week-old redheads were liberated. In 1958, 539 were released, of which 158 were adults released in the spring and the remainder were 5-week-old ducklings liberated in August and September. In the spring of 1959, 592 adult redheads were released.

Of the 5-week-old ducklings liberated in 1957, 63 per cent survived to flight age, and 25 per cent were reported retaken during their first year. Estimating that only half of those taken were reported, or that approximately 130 birds were actually taken from a known number of surviving flight-age ducklings, then only about 38 birds of the original 260 were available to return and repopulate their release sites. About five were known to return, and there was some indication that one brood was produced.

Of the 158 adults liberated in 1958, 75 were released as pairs. Five nests were subsequently observed together with several other pairings and territorial selections, but only one brood was successfully brought off. Most of the birds remained in close groups until they could fly (after the molt) and soon thereafter left their areas. Some 68 per cent of the young released in 1958 were known to have survived, but instead of remaining on or close to the site of release after flight age, they left and were not observed thereafter.

Reported recoveries for the adults released in 1958 amounted to 22 per cent and for the ducklings the proportion was nearly 20 per cent. Therefore, only a slightly better prospect for establishment was indicated by the results of the releases made in 1958 compared with those in 1957. Neither was encouraging.

At least two broods were produced by the adults released in 1959.

Even though the redheads dispersed more widely from the release site than did the mallards, they suffered nearly as great reported mortality, especially those which moved across the border into Ontario and Quebec where the hunting seasons began in September. This was true of both the adults and juveniles. To build up a breeding population it would seem necessary to protect the birds in some way during the first season at least. Besides New York and the two Canadian provinces mentioned, the only other area of consequential harvest was Maryland.

The various other species released were liberated only coincidentally to the redheads and in numbers too small to be meaningful.

LITERATURE CITED

Benson, D. and D. Foley. 1956. Waterfowl use of small, man-made wildlife marshes in New York State. N. Y. Fish and Game Jour. 3(2): 217–224.

Foley, D. 1954a. Studies on survival of three strains of mallard ducklings in New York State. N. Y. Fish and Game Jour. 1(1): 75–83.

———————— 1954b. Survival and establishment of waterfowl released as ducklings. N. Y. Fish and Game Jour. 1(2): 206–213.

Lincoln, F. C. 1934. Restocking of marshes with hand-reared mallards not proved practicable. U. S. D. A. Yearbook: 310–313.

Mason, C. I. 1947. Organization and correlation of New York waterfowl banding records. Fed. Aid Project W-21-R. Final Report (mimeo.) N. Y. S. Cons. Dept.

EFFECT OF LIGHT, DIET, AND AGE OF SPAWNING BROWN TROUT UPON CERTAIN CHARACTERISTICS OF THEIR EGGS AND FRY

Richard F. Dumas Conservation Biologist
New York State Conservation Department

ABSTRACT

Studies were carried on to determine the effect of light, diet and age of spawning fish on the physical and chemical characteristics of developing brown trout eggs. It was found that all three factors influenced the relative weight and size of eggs, but that the nutrition and age of breeders were the only ones, of those studied, that affected the chemical composition of eggs and fry.

Fisheries workers have long believed that developing trout eggs increase in weight and diameter during incubation. These opinions have not always been based upon experimental evidence and very little experimental work has been done on the physical characteristics of developing trout eggs. Tingley (1941) reported a slight increase in the volume of Atlantic salmon eggs during incubation, while Phillips *et al.* (1955) reported a slight decrease in weight among trout eggs as incubation progressed and described chemical changes that occur during incubation.

In addition to the possible physical and chemical changes normal to development, there may be physical and chemical differences in the eggs which could be a reflection of the prior history of the brood stock. These studies were designed to determine the effects of light, diet and age of the spawning fish on the physical and chemical characteristics of developing eggs of brown trout (*Salmo trutta*). They were carried on at the Cortland Fish Hatchery.

METHODS

Four groups of brown trout spawners were used as egg sources for these studies.

1. First-spawning trout fed the standard hatchery diet[1] and held under natural light. This was the control group.
2. First-spawning trout fed a pellet and meat diet[2] and held under natural light.
3. First-spawning trout fed the standard hatchery diet and held under controlled light to advance spawning approximately one month.
4. Second-spawning trout fed the standard hatchery diet and held under controlled light.

[1] Consisted of 27 per cent each of beef liver and spleen; 11 per cent of whitefish meal, distiller's solubles, wheat middlings, and cottonseed meal; 2 per cent salt.

[2] Cortland pellets (Phillips *et al.*, 1953) were fed five days a week, and beef liver and spleen (49 per cent each) plus salt (2 per cent) were fed two days a week.

Replicated populations, consisting of two groups of 6,000 eggs each, were collected from each of the above lots of brood fish and held on a divided hatching tray (6,000 eggs on each side) in water having a constant temperature of 47° F. To assure a fresh water supply, each tray of eggs was placed in a separate hatching trough which was one-third the standard length.

Standard hatchery methods were followed during incubation of the eggs. To eliminate the possibility of drugs affecting the chemical composition of the eggs or fry, fungus was controlled by manually picking out dead eggs rather than by chemical treatment.

Starting 1 week after spawning, weekly samples were taken from each replicate of each population. For the first seven weeks, samples consisted

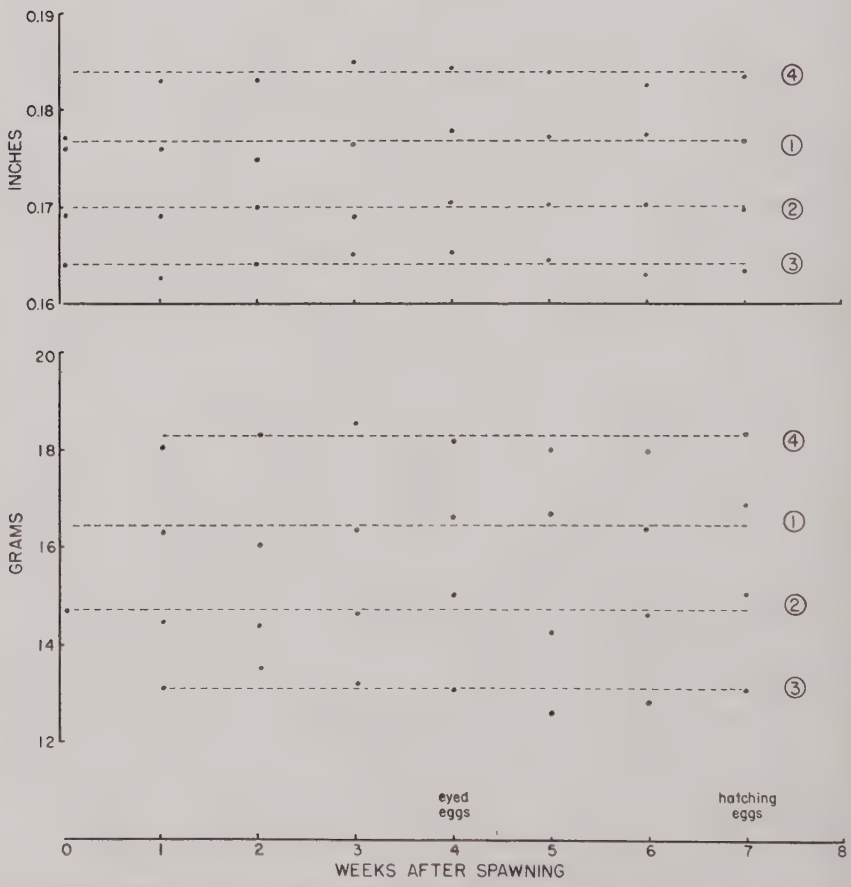


Figure 1. Effect of light, diet and age of spawning brown trout on their developing eggs: (lower) weight of 300-egg samples; (upper) average diameter of individual eggs. In each case, circled numbers indicate breeder groups as designated in the text; dotted lines identify series of values for each group.

of 300 eggs. The eggs reached the "eyed" stage at 4 weeks and were hatching at 7 weeks after spawning. Samples of 300 fry were taken at 8, 9 and 10 weeks.

The diameter of a single egg was determined by the method of Von Bayer (1910) with the aid of a conversion table adapted for direct diameter reading. This determination was made three times for each replicate sample and the average of the three values was considered to be the egg diameter. Separate groups of eggs were used for each diameter determination.

After gently rolling on a sheet of filter paper to remove the surface water, the entire sample of eggs or fry was weighed to one-tenth of a gram. The weighing was accomplished as rapidly as possible to avoid dessication. Results of the weight and diameter determinations are summarized in Table 1 and Figure 1.

TABLE 1. EFFECT OF LIGHT, DIET AND AGE OF SPAWNING FISH ON THE WEIGHT AND DIAMETER OF DEVELOPING BROWN TROUT EGGS

Source of eggs*	Weeks after spawning						
	1	2	3	4	5	6	7
	Diameter of eggs in inches (per individual egg)						
Group 1.....	0.176	0.175	0.177	0.178	0.176	0.178	0.177
	0.176	0.175	0.176	0.178	0.177	0.177	0.177
Group 2.....	0.169	0.170	0.169	0.170	0.169	0.170	0.170
	0.169	0.170	0.169	0.171	0.171	0.170	0.169
Group 3.....	0.163	0.164	0.165	0.165	0.165	0.163	0.163
	0.162	0.164	0.165	0.166	0.164	0.163	0.164
Group 4.....	0.184	0.184	0.185	0.186	0.183	0.183	0.185
	0.182	0.182	0.185	0.185	0.184	0.182	0.184
	Weight of eggs in grams (per 300-egg sample)						
Group 1.....	16.5	16.0	16.4	16.7	16.3	16.3	17.2
	16.2	16.1	16.4	16.7	17.1	16.5	16.6
Group 2.....	14.2	14.4	14.5	15.0	14.3	14.8	15.7
	14.7	14.4	14.8	15.1	14.3	14.5	14.6
Group 3.....	13.3	13.3	13.3	13.1	12.7	12.9	13.5
	13.0	13.7	13.2	13.1	12.6	12.9	12.8
Group 4.....	18.3	18.8	18.5	18.1	18.2	18.0	18.5
	17.8	17.9	18.7	18.3	17.8	18.0	18.3

* Two replications in each group.

After weighing, the eggs or fry were preserved in 95 per cent ethyl alcohol to await chemical analyses.

The water content of the samples was determined by drying in a vacuum oven; fat, by continuous ether extraction; ash, by ignition to constant weight at 600° C.; and protein, by the micro-Hengar method. The results of these analyses are summarized in Table 2. All values are averages of duplicate analyses on duplicate samples.

Significant differences in chemical components of eggs and fry were established by analysis of variance.

Table 3 lists the chemical composition of the ingredients in the diets used in this study. The percentages of the ingredients are based upon total weekly feedings. This manner of expression is necessary because pellets were fed at a rate of 60 per cent of that in the feeding tables (Deuel *et al.*, 1952) five days a week, and meat supplement at 100 per cent of the rate in the feeding tables two days a week. The standard hatchery diet was fed at 100 per cent of the feeding table values.

DISCUSSION

The data pertaining to physical and chemical characteristics are discussed separately.

Physical Characteristics

Throughout the period of incubation fluctuations in weight and diameter were found between weekly samples of each egg population, but fluctuations of equal or greater magnitude were found within replicate samples of individual populations. This was interpreted to mean that there were no important differences in weight or diameter of eggs within a population during incubation.

Tingley (1941) hypothesized that the increase in volume that he noted might have been caused by an increase in the adhesive properties in the shell of the egg during incubation, allowing the "green" eggs to "pack" more tightly in the measuring device than the eggs nearing the hatching stage. This adhesive property was also noted during the present study. The "green" eggs rolled freely over the filter paper during the removal of excess moisture, while the more advanced eggs tended to cling to the filter paper and resist movement. But changes in adhesiveness of the shells had no effect upon the diameter measurements in the present study since a Von Bayer trough and not a volumetric vessel was used to determine egg diameter.

As illustrated in Table 1 and Figure 1, the obvious variation was between groups of spawning fish. Conditions of light exposure, diet, and the age of the spawning fish significantly affected the weight and diameter of the eggs. The weight and diameter differences of the various lots of eggs were distinct and did not overlap. In all experiments, a greater

Weeks after spawning	Fat				Ash				Protein				Water			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Dry basis																
1	12.0	13.3	11.9	11.2	3.9	4.1	4.0	4.3	73.3	71.3	71.5	71.4	....	....	....	....
2	11.5	12.3	10.5	11.0	3.9	4.1	4.0	4.1	73.2	70.6	64.5	66.3	....	....	....	....
3	10.6	12.2	10.4	11.1	4.2	4.1	4.1	4.2	72.8	66.7	67.2	70.0	....	....	....	....
4	9.6	11.8	10.5	10.4	4.3	4.1	4.2	4.2	69.5	71.8	69.2	74.1	....	....	....	....
5	11.1	13.0	11.8	11.8	4.4	4.2	4.2	4.3	73.7	71.0	66.4	70.9	....	....	....	....
6	13.6	13.7	12.0	12.3	4.3	4.3	4.3	4.3	75.2	68.9	68.6	70.8	....	....	....	....
7	10.4	14.7	11.6	11.2	4.5	4.5	4.4	4.4	77.0	70.8	68.6	69.6	....	....	....	....
8	12.8	14.3	13.6	12.2	4.7	4.8	4.8	4.8	72.1	68.0	74.6	72.2	....	....	....	....
9	12.7	16.6	16.2	15.1	5.3	4.9	5.1	5.0	73.2	67.8	75.6	72.6	....	....	....	....
10	15.4	19.5	16.4	17.0	5.8	5.6	5.7	5.8	71.6	74.2	77.6	76.3	....	....	....	....
Wet basis																
1	4.1	4.7	4.6	3.7	1.3	1.4	1.5	1.4	25.1	25.2	27.0	23.5	65.7	64.7	62.0	67.0
2	3.9	4.5	3.7	3.7	1.3	1.5	1.4	1.3	25.3	25.7	22.9	22.2	65.4	63.5	66.4	66.7
3	3.6	4.4	3.6	3.6	1.4	1.5	1.4	1.3	24.8	23.9	23.6	22.4	65.8	64.2	64.9	68.0
4	3.2	4.1	3.8	3.4	1.4	1.4	1.5	1.4	23.1	24.7	25.3	24.4	66.8	65.4	63.4	67.0
5	3.7	4.7	4.5	3.9	1.5	1.5	1.6	1.5	25.1	25.8	25.4	23.7	65.8	63.6	61.7	66.4
6	4.8	4.7	4.4	4.2	1.5	1.5	1.4	1.5	26.9	23.7	25.3	24.0	65.2	65.5	63.2	66.1
7	3.0	5.1	4.0	3.5	1.5	1.5	1.5	1.4	25.7	24.3	24.0	22.0	66.2	65.5	65.0	68.5
8	3.6	4.2	2.9	2.8	1.3	1.4	1.0	1.1	20.6	20.1	16.0	16.7	71.4	70.4	78.5	76.8
9	3.3	4.4	3.6	3.8	1.4	1.3	1.1	1.3	18.9	17.9	16.6	17.8	74.1	73.3	77.9	74.2
10	3.3	4.2	3.4	3.5	1.5	1.2	1.2	1.2	15.3	15.9	16.1	15.7	77.8	78.6	79.2	79.4

* Four columns under each substance represent groups of fish studied; values expressed in per cent.

weight was accompanied by a greater diameter. The lightest and smallest eggs were produced by the first-spawning trout that were subjected to controlled light. Perhaps this may be attributed to the shortening of the growing period of the eggs by one month through light control, thus forcing maturation of the eggs before they reached the size of eggs from fish under natural light. The heaviest and largest-diametered eggs were produced by trout spawning their second time and held under controlled light.

A pellet and meat diet, fed to first-spawning trout held under natural light, resulted in the production of eggs lighter and smaller than eggs from similar trout also held under natural light but fed the standard hatchery diet. Unfortunately, second-spawning trout, held under natural light and fed the standard hatchery diet were unavailable for comparison in these studies.

Chemical Characteristics

Eggs and fry from brood stock fed a pellet and meat diet contained a significantly higher percentage of fat (wet and dry basis) and a significantly lower percentage of protein (dry basis) than eggs and fry from brood stock fed the standard hatchery diet. Percentages of ash (wet and dry basis) and water were similar in the eggs and fry from both groups of fish.

Eggs and fry from first-spawning fish held under controlled light were similar in percentages of chemical components to those from first-spawning fish held under natural light. Since both brood stocks received the standard hatchery diet, light control over the parents apparently had no affect upon the chemistry of the eggs or fry.

Eggs and fry from first- and second-spawning fish, held under controlled light and fed the standard hatchery diet, differed only in the percentages of water and fat (wet basis). The percentages of fat in both groups were similar on a dry basis. The percentage of fat was slightly lower for the second spawners, but the percentage of water was higher, thus indicating that the fat variation was due to water content.

Since the fat content of the pellet and meat diet is nearly equal to that of the standard hatchery diet (Table 3), some other dietary ingredient or ingredients must have been converted to form the greater amount of fat found in the offspring from brood stock fed the pellet and meat diet.

The pellet and meat diet is slightly higher in protein than the standard hatchery diet. Since excessive dietary protein or protein of poor quality may be converted to fat, this difference in dietary protein may account for some of the fat found in the eggs and fry from brood stock fed pellets and meat.

The pellet and meat diet contains 23.0 per cent carbohydrate while the standard hatchery diet used contains 17.7 per cent, a difference of 5.3 per cent (Table 3). The carbohydrate found in beef liver and white-

TABLE 3. INGREDIENTS OF THE TWO DIETS FED THE SPAWNING FISH AND THE CONTRIBUTION OF EACH INGREDIENT TO THE COMPOSITION OF THE MIXTURE

Ingredient	Pellet and meat diet						Standard diet					
	Percentage of weekly ration *	Composition					Percentage of weekly ration §	Composition				
		Protein	Ash	Fat	Carbohydrate	Water		Protein	Ash	Fat	Carbohydrate	Water
Beef liver	19.0	3.8	0.2	0.6	0.5	13.7	27.0	5.4	0.4	0.8	0.7	19.5
Beef spleen	19.0	3.4	0.3	0.4	....	14.3	27.0	4.9	0.4	0.6	....	20.3
Whitefish meal	14.4	9.8	2.7	0.3	0.5	1.4	11.0	7.5	2.1	0.2	0.4	1.1
Wheat middlings	14.4	2.6	0.5	0.7	9.0	1.4	11.0	2.0	0.4	0.6	6.9	1.1
Distiller's solubles	10.2	2.5	0.8	0.5	4.9	1.0	11.0	2.8	0.8	0.6	5.3	1.1
Cottonseed meal	9.0	3.4	0.6	0.7	3.6	0.9	11.0	4.2	0.7	0.9	4.4	1.1
Dried brewer's yeast	6.0	1.5	0.7	0.0	2.4	0.5	0.0	....	....	....	....	....
Dried skim milk	4.2	1.5	0.3	0.0	2.1	0.3	0.0	....	....	....	....	....
Fish liver oil	1.8	....	....	....	....	....	0.0	....	....	....	....	....
Salt	2.0	....	2.0	....	....	....	2.0	....	2.0	....	....	....
Total	100.0	28.5	8.1	3.2	23.0	35.9	100.0	26.8	6.8	3.7	17.7	44.2

* Calculated on the basis of feeding pellets five days each week at 60 per cent of the level given in the table for trout (Deuel *et al.*, 1952) and feeding the meat mixture two days each week at 100 per cent of the level given in the table.

§ Fed at 100 per cent of the level given in the above table.

fish meal is largely glycogen and, because of autolysis upon death of the animal, the glycogen may be ignored as a source of carbohydrate. The carbohydrate of distiller's solubles is largely nonfermentable sugar and unavailable to trout. Therefore, 15.0 per cent of the pellet and meat diet is available as carbohydrate, while 11.3 per cent of the standard hatchery diet is available as carbohydrate. Of these available carbohydrates, that of dried skim milk is lactose which is 60 per cent digestible by trout (Phillips *et al.*, 1948). Trout digest 38 per cent of uncooked starch and 47 per cent of cooked starch (Phillips *et al.*, 1948). The starch in the meals used in pellets may be cooked by the pelleting process and, therefore, becomes more digestible by trout. If the starch remained uncooked, 7.0 per cent of the pellet and meat diet would be digestible carbohydrate (starch and lactose).

The standard hatchery diet contains 4.3 per cent digestible carbohydrate (starch). If the starch were cooked in the pelleting process, then 8.3 per cent of the pellet and meat diet would be digestible carbohydrate, nearly twice the amount found in the standard hatchery diet. The greater amount of digestible carbohydrate, whether cooked or raw, together with the higher percentage of protein, may be sufficient to increase the fat content of the eggs and fry from brood stock fed pellets and meat.

CONCLUSIONS

The data seem to indicate that the previous history of the brown trout breeding stock can effect the physical and chemical characteristics of its eggs and fry. Conditions of light, nutrition, and age of the breeders determine the relative weight and size of eggs, while the nutrition and age of breeders are the only factors of those studied which apparently affect the chemical composition of their offspring.

Should fisheries workers ever ascertain the optimum percentages of ash, fat, protein and water which need to be present to give the best survival and hardiness to eggs and the resulting fish, then a diet might be formulated to meet these requirements.

LITERATURE CITED

Deuel, C. R., D. C. Haskell, D. R. Brockway and O. R. Kingsbury. 1952. The New York State fish hatchery feeding chart. Fish. Res. Bull. No. 3, N. Y. S. Cons. Dept., Albany.

Phillips, A. M., Jr., A. V. Tunison and D. R. Brockway. 1948. The utilization of carbohydrates by trout. Fish. Res. Bull. No. 11, N. Y. S. Cons. Dept., Albany.

Phillips, A. M., Jr., D. R. Brockway, F. E. Lovelace and G. C. Balzer. 1953. Cortland Hatchery Report No. 22, N. Y. S. Cons. Dept., Albany.

Phillips, A. M., Jr., F. E. Lovelace, H. A. Podoliak, D. R. Brockway and G. C. Balzer. 1955. Cortland Hatchery Report No. 24, N. Y. S. Cons. Dept., Albany.

Phillips, A. M., Jr., H. A. Podoliak, R. F. Dumas and R. W. Thoesen. 1958. Cortland Hatchery Report No. 27, N. Y. S. Cons. Dept., Albany.

Tingley, F. A. 1941. Changes in volumetric measurement of salmon eggs. Trans. Am. Fish. Soc. 71: 284.

Von Bayer, H. 1910. A method of measuring fish eggs. Bull. U. S. Bur. Fish. 28(2): 1011.

THE TOXOID OF *CLOSTRIDIUM BOTULINUM* AS A MEANS OF IMMUNIZING PHEASANTS AGAINST AVIAN BOTULISM[1]

James R. Reilly — Game Pathologist, New York State Conservation Department

Daniel A. Boroff — Microbiologist, New England Institute for Medical Research

ABSTRACT

In a previous paper it was shown that pheasants could be effectively immunized against the toxin of *Clostridium botulinum* type C with two separate injections of formalinized toxoid mixed with Freund's incomplete adjuvant. This procedure affords protection against 2,000 LD_{50} pheasant doses of the toxin administered by the intraperitoneal or intramuscular routes. In the present study the concentration of toxin which pheasants, immunized with two injections of a toxoid-incomplete adjuvant mixture, could withstand was determined to be 600 oral doses. In a field experiment, terminated by cool weather after a week, 30 of 250 unimmunized and 6 of 250 immunized birds succumbed to botulism intoxication.

A previous paper (Boroff and Reilly, 1959) discussed the feasibility of prophylactic immunization of pheasants and ducks against botulism intoxication. Active immunity against as much as 2,000 LD_{50} bird doses of the toxin of *Clostridium botulinum* type C, administered either intramuscularly or intraperitoneally, was established by a two-injection procedure using 1 milliliter of formalinized toxoid mixed with an equal amount of Freund's incomplete adjuvant (Freund and Bonanto, 1944). However, a number of questions remained unanswered, such as whether this degree of protection would suffice in an actual outbreak and what concentration of the toxin immunized pheasants would withstand when challenged orally. Finally, a question was raised by a recent paper by Prévot and Sillioc (1958) who stated that they had succeeded in inducing a high degree of protection in mink with one injection of alum-precipitated toxoid. Such a method would be of great practical value in game farm operations. This study was undertaken to investigate the effectiveness of the two-injection procedure under field conditions and to determine the feasibility of a one-injection procedure with alum-precipitated or adjuvant-mixed toxoid.

MATERIALS AND METHODS

The strain of *C. botulinum* type C used in this study was obtained from Dr. Prévot of the Pasteur Institute (Paris, France) who isolated it from an outbreak of botulism among horses in France. It is of the *beta* variety and possesses some characteristics of *C. boulinum* type D. This organism was cultured in saline in a dialyzing sack immersed in a 3 per cent cornsteep liquor according to a method described by Sterne (Sterne and Wentzel, 1950) and modified by Boroff (1955). After 10 days incubation at 37° C. the content of the dialyzing sack was centrifuged and filtered to

[1] A contribution of Federal Aid in Fish and Wildlife Restoration Project W-35-R.

free it from organisms. The filtrate which constituted the crude toxin was titrated in 18- to 20-gram white mice and found to contain the equivalent of 500,000 mouse LD_{50} per milliliter or 10,000 pheasant LD_{50} administered by the intramuscular route (Boroff and Reilly, 1959).

To produce the toxoid for use in this study, enough formalin was added to the crude toxin to make a concentration of 0.5 per cent, and the mixture was then incubated at 37° C. for 30 days. The alum-precipitated toxoid was prepared by adding 7 milligrams of alum (potassium aluminum sulfate) per milliliter of this toxin. For immunization purposes the formalinized toxoid was mixed in a blendor in equal amounts with 85 per cent Bayol F (Esso Standard Oil Company) and 15 per cent Arlacel-A (Atlas Powder Company) until a creamy suspension was obtained.

RESULTS

The results achieved with each procedure are discussed separately.

Effectiveness of Two Injections of Toxoid-adjuvant

Since the portal of entry in botulism intoxication is oral, the first step was to establish the degree of protection afforded to pheasants by two injections of the toxoid against an oral challenge. To determine the relationship between oral and intramuscular doses, the toxin in graded doses was administered to pheasants with the aid of a long metal cannula which reached well into the esophagus of the birds. By this method it was established that 1 oral dose equals 10 intramuscular LD_{50}.

To determine the resistance of immunized pheasants to oral challenge, five groups of 20 birds each were immunized with two 2-milliliter injections of toxoid-adjuvant 20 days apart. Each group was challenged orally with a different dilution of toxin 30 days after the last injection. Table 1 demonstrates that pheasants survived 6,000 intramuscular LD_{50} or 600 oral doses.

The next question to be considered was whether this degree of immunity would suffice in an actual outbreak under field conditions. For this phase of the study 250 pheasants were immunized with two injections of toxoid-incomplete adjuvant mixture given 2 weeks apart. Thirty days after the final injection they were banded and released in a 1-acre field enclosure together with 250 unimmunized pheasants from the same hatch. To trigger the experiment, four normal pheasants were fed 1 milliliter of whole culture including toxin of *C. botulinum* type C and released in the experimental field. These birds were dead the next day. The weather was hot and humid, and in a very short time the dead birds became fly blown and swarmed with maggots on which the experimental birds were observed feeding. The field was surveyed twice daily for sick and dead birds; the first ones were observed two days later. In a week's time 36 dead pheasants were found. Of these, 30 were unimmunized and six

TABLE 1. DEGREE OF RESISTANCE OF PHEASANTS IMMUNIZED WITH TWO INJECTIONS OF TOXOID-ADJUVANT TO THE TOXIN OF *C. botulinum* GIVEN ORALLY *

Oral challenge of toxin §	Number of pheasants	
	Immunized	Surviving challenge
20	20	20
200	19†	19
2,000	19†	18
4,000	20	18
6,000	20	20

* Relation of oral dose to intraperitoneal or intramuscular LD_{50} is 1:10.
§ In terms of intramuscular LD_{50}.
† One bird died of injuries before being challenged.

were immunized. Unfortunately, the heat and humidity subsided, and with that the spread of botulism terminated. It is realized that this number of affected pheasants is insufficient for statistical analysis. Nonetheless, since all of them were equally exposed to the intoxication, the disproportionate number of unimmunized birds affected is, perhaps, indicative of what might have happened had the high temperature and humidity continued and an epidemic developed.

Merton N. Rosen of the California Department of Fish and Game, who has been conducting similar experiments in that state with 10,000 pheasants, has reported (Rosen, 1959) that in a naturally occurring botulism epidemic 20 per cent of the deaths occurred among the unimmunized birds compared with 3 per cent among the immunized pheasants. Limited observations in our experiment seem to bear out this ratio.

EFFECTIVENESS OF ONE INJECTION OF ALUM-PRECIPITATED TOXOID

Sixty pheasants were injected with alum-precipitated toxoid, and 60 others were injected with toxoid mixed with Freund's incomplete adjuvant. The former group received 1 milliliter of the suspension intraperitoneally and the latter group received 2 milliliters of toxoid-adjuvant mixture. Half the birds in each group were challenged with five concentrations of the toxin (six birds in each case) 20 days after the immunizing injection and the other half were challenged 30 days later. Table 2 shows the results for the birds challenged after 20 days; results for the others did not differ significantly. For the purpose of comparison, data obtained in previous work with the two-injection procedure have been included in this table. It is clear that the protection afforded with the

Table 2. Comparative Immunity Established in Pheasants by Injections of Toxoid-adjuvant and Alum-precipitated Toxoid at Different Rates *

Intramuscular challenge of toxin §	Immunity established †		
	Two injections of toxoid-adjuvant	One injection of toxoid-adjuvant	One injection of alum toxoid
20	6/6	5/6	1/6
200	6/6	4/6	1/6
2,000	6/6	2/6	0/6
4,000	0/6	0/6	0/6
6,000	0/6	0/6	0/6

* Challenged 20 days after immunization.
§ In terms of LD_{50}.
† Survival over number challenged.

two-injection procedure is superior to that obtained with one injection of the toxoid adjuvant. Alum-precipitated toxoid was much poorer as an antigen.

CONCLUSIONS

It appears that one injection of toxoid-adjuvant inoculum induces some resistance and antibody formation against botulinus toxin prepared from the toxin of *C. botulinum* type C, but not to the high degree achieved by two-injections. The alum-precipitated toxoid used did not appear to be as good an antigen. The protection afforded by two injections of toxoid-adjuvant may be sufficient to protect the majority of a group of pheasants against an actual outbreak of botulism under field conditions. Finally, temperatures and high humidity with the accompanying rapid decomposition of organic material seem to be important elements in the outbreak of botulism on game farms.

LITERATURE CITED

Boroff, D. A. 1955. Study of toxins of *Clostridium botulinum*. III. Relation of autolysis of toxin production. J. Bacteriol. 70: 363–367.

Boroff, D. A. and Reilly, J. R. 1959. Studies of the toxin of *Clostridium botulinum* V. Prophylactic immunization of pheasants and ducks against avian botulism. J. Bacteriol. 77: 142–146.

Freund, J. and Bonanto, M. V. 1944. Effect of paraffin oil, lanolin-like substance and killed tubercle bacilli on immunization with diptheria toxoid and *Bacterium typhosum*. J. Immunol. 48: 325–334.

Prevót, A. R. and Silliog, R. 1958. Recherches sur l'immunisation antibotuliqu C_B du lapin par injection unique d'anatoxine concentrée adsorbée. Ann. Inst Pasteur. 95: 208–211.

Rosen, M. N. 1959. Immunization of pheasants with butolinum toxoid. Calif Fish and Game. 45: 343–350.

Sterne, W. and Wentzel, L. M. 1950. A new method for the large scale production of high titer botulinum formol-toxoid types C and D. J. Immunol. 65: 175–183.

GENERAL NOTES

A METHOD FOR DETERMINING THE FREQUENCY OF WINTERKILLED DEER PER SQUARE MILE [1]

C. W. Severinghaus Conservation Biologist
New York State Conservation Department

Surveys are made each spring in the major deer wintering grounds in New York to determine the relative effects of winter on the deer population. The number of dead deer found is of little significance unless it can be accurately correlated with the area searched. The following method is used to meet this requirement and to standardize the data recorded by different field crews.

MAPS AND NOTES

Outline maps of the areas to be surveyed are made (usually by tracing) using U. S. Geological Survey maps as the base. Streams, lakes, ponds, trails, roads and other landmarks are the principal features transcribed. In addition, the name of the wintering area, county and township, U. S. G. S. quadrangle, map scale and compass bearing are noted on each map.

On a copy of the map for the area being surveyed, a field crew plots its exact travel route through the deer wintering ground using a dash line and arrows. The locations of dead deer found and of other pertinent observations are marked by consecutive numbers that correspond to numbered field notes kept separately. The names of the crew are also noted; but interested individuals who may accompany it without actually functioning in the survey should not be counted. And the width of the strip within which each man is responsible for observations is recorded.

In plotting the survey route, the starting and ending points of the actual search for dead deer are used; routes walked in getting to and from those points should not be included. The route and directions depicted by the dash lines and arrows should represent the middle of the course walked by the crew, not individual members. There may be occasions when a crew will split, e.g., one or more members following one side of a watercourse and the others the opposite side. In such cases, both routes are indicated on the map together with numbers corresponding to field notes describing where and how the crew was split.

SURVEY PROCEDURE

For New York conditions, crews of two or four men have been found most practical. The width of strip covered by each man has been standardized in units of 75, 100, 150 or 200 feet. This is the full distance including both sides of the line he walks. For example, a 100-foot-wide strip would mean 50 feet on either side of the line was covered for dead deer. Surveys for dead deer are usually impractical when visibility is so poor that individuals cannot cover a strip 75 feet wide; the linear distance that would have to be traveled would be too great.

As long as leafy growth from herbaceous vegetation, shrubs and trees has not developed enough to obscure dead deer, each man in the crew walks a line about 200 feet from his companion. In surveying a winter shelter belt, the man nearest the stream, lake or other guide being followed walks about 100 feet from it. However, this man must be certain that he makes a complete coverage of his strip because the number of dead deer along such edges is often greater than farther inside the woods. Each man must of necessity walk a crooked line because, in locating dead deer on his 200-foot-wide strip, he will frequently find it necessary to look under, behind or around things that obscure his view. Because many deer die in locations that are exposed to the warm sunlight between noon and sundown, openings in the woods, variations in the contour of the land, etc., that favor afternoon warm spots must be examined carefully.

CALCULATING FREQUENCY OF DEAD DEER

As has been mentioned, the width of the strip covered by each crew member is recorded on the map. This, rather than the total for the crew as a whole, is used in calculating the frequency of dead deer per square mile. Calculations are made as follows:

---

[1] A contribution of Federal Aid in Fish and Wildlife Restoration Project W-89-R.

Table for Determining the Number of Square Miles Surveyed

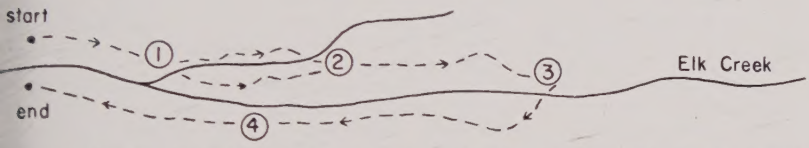
Total linear mileage *	Width of strip covered by each crew member (feet) §			
	75	100	150	200
¼	0.0035	0.0047	0.0071	0.0094
½	0.0071	0.0095	0.0142	0.0189
¾	0.0106	0.0142	0.0213	0.0284
1	0.0142	0.0189	0.0284	0.0378
2	0.0284	0.0379	0.0568	0.0758
3	0.0426	0.0568	0.0852	0.1136
4	0.0568	0.0758	0.1136	0.1515
5	0.0710	0.0947	0.1420	0.1894
6	0.0852	0.1136	0.1705	0.2273
7	0.0994	0.1326	0.1989	0.2652
8	0.1136	0.1515	0.2273	0.3030
9	0.1278	0.1705	0.2557	0.3409
10	0.1420	0.1894	0.2841	0.3788
11	0.1562	0.2083	0.3125	0.4167
12	0.1704	0.2273	0.3409	0.4545
13	0.1846	0.2462	0.3693	0.4924
14	0.1988	0.2652	0.3977	0.5303
15	0.2130	0.2841	0.4261	0.5682
16	0.2272	0.3030	0.4545	0.6061
17	0.2415	0.3220	0.4830	0.6439
18	0.2557	0.3409	0.5114	0.6818
19	0.2699	0.3598	0.5398	0.7197
20	0.2841	0.3788	0.5682	0.7576
21	0.2983	0.3977	0.5966	0.7955
22	0.3125	0.4167	0.6250	0.8333
23	0.3267	0.4356	0.6534	0.8712
24	0.3409	0.4545	0.6818	0.9091
25	0.3551	0.4735	0.7102	0.9470
26	0.3693	0.4924	0.7386	0.9848
27	0.3835	0.5114	0.7670	1.0227
28	0.3977	0.5303	0.7955	1.0606
29	0.4119	0.5492	0.8239	1.0985
30	0.4261	0.5682	0.8523	1.1364
31	0.4403	0.5871	0.8807	1.1742
32	0.4545	0.6061	0.9091	1.2121
33	0.4687	0.6250	0.9375	1.2500
34	0.4829	0.6439	0.9659	1.2879
35	0.4971	0.6629	0.9943	1.3258
36	0.5113	0.6818	1.0227	1.3636
37	0.5255	0.7008	1.0511	1.4015
38	0.5397	0.7197	1.0795	1.4394
39	0.5540	0.7386	1.1080	1.4773
40	0.5682	0.7576	1.1364	1.5152
41	0.5824	0.7765	1.1648	1.5530
42	0.5966	0.7955	1.1932	1.5909
43	0.6108	0.8144	1.2216	1.6288
44	0.6250	0.8333	1.2500	1.6667
45	0.6392	0.8523	1.2784	1.7045
46	0.6534	0.8712	1.3068	1.7424
47	0.6676	0.8902	1.3352	1.7803
48	0.6818	0.9091	1.3636	1.8182
49	0.6960	0.9281	1.3921	1.8561

* Length of survey route multiplied by number in crew.

§ Includes both sides of line walked by individual, i.e., 100-foot width represents 5
feet either side of line.

1. Using a map measurer, determine the length of the route lines plotted. From this compute (to the nearest ¼ mile) the corresponding number of miles.
2. Multiply this mileage by the number in the survey crew to get the total linear miles traveled for the strip width used. Adjustments must be made for any instances in which the crew split up for a portion of the route.
3. Determine from the accompanying table the number of square miles covered, i.e., the figure in the appropriate column for the width of strip covered and opposite the total linear mileage as derived in Step 2.
4. Total the dead deer found and compute the number per square mile.

A typical example may be used to illustrate. Suppose a two-man crew walked survey route of 14 miles or 28 total linear miles. If they each covered a 150-foot-de strip, the corresponding number of square miles (see table) would be 0.7955. If dead deer had been found, the frequency would be 7.5 per square mile.



presentative sketch of deer yard survey route showing manner of indicating perti-nt notes.

LABORATORY MANUFACTURE OF FISH BAITS FOR EXPERIMENT PURPOSES [1]

Howard A. Loeb — Conservation Biologist
New York State Conservation Department

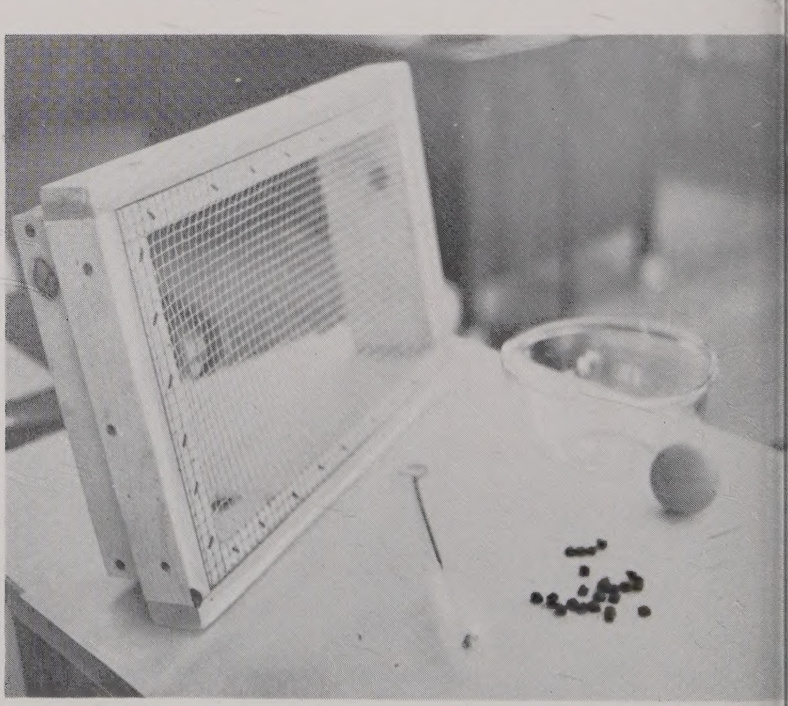
William H. Kelly — Conservation Biologist
New York State Conservation Department

An efficient method of making small lots of experimental baits has been develo at the Fish Laboratory at Livingston Manor (N. Y.) and has been adapted for us the Fish Disease Laboratory at Rome (N. Y.).

The baits vary in size from ⅛ to ½ inch in diameter and have been used to st the feeding habits of carp in aquaria and ponds and to test the effect of various m cines on diseased trout. The finished dry baits are quite uniform in size and sh and are easily stored.

The larger baits, used for carp feeding, are made from varying amounts of w flour, gluten flour, corn meal and animal-feed flours with desired amounts of poi and/or tracer food dyes added. Baits containing 40 to 50 per cent white flour made from hard dough, and hold together in water for 2 days or longer, or until t begin to ferment and mold. Smaller baits made from corn meal or animal feeds softer in dough form and last for 10 to 20 minutes in water before disintegrat This period is long enough for experiments with trout.

The ingredients are mixed in a mechanical tumbler or a plastic bag in 5 10-pound lots. A quart of the mix is made into a dough by adding water and knea with a broad spatula and gloved hands. Toxic materials are handled in a fume h and the kneading is done entirely by spatula. The dough is rolled out on the b of a pan with a glass jar. The resulting sheet of dough is placed on hardware c of desired mesh size and pressed through by rolling a rubber ball over it. The ha ware cloth itself is stapled to a sturdy frame of 2 x 4s, and the edges are turned u to prevent damage to hands and gloves. The hanging baits are loosened by rapp



Equipment for making fish baits and some of the baits produced.

[1] A contribution of Federal Aid in Fish and Wildlife Restoration Project F-9-R.

th a light, stiff-bristled nylon brush and drop to a pan below where they are allowed dry. The few dried baits which stick together are broken apart by pressing with e base of a bottle. Larger baits dry in 2 days and are turned with a brush or broom ter the first day to prevent the growth of molds. Small baits dry in half a day. n oven can be used to speed drying.

Pure food dyes for tracing can be purchased in powder form. The baits maintain eir bright colors until disintegration occurs.